THE IMPACT OF COGNITIVE STYLE ON ACHIEVEMENT IN MATHEMATICS   IN SECONDARY SCHOOLS IN KENYA

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WORK DECLARATION

I declare that the work in this research project is entirely my original work and has never been presented for any academic award in any other university.

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E58/63762/2013

This research has been submitted for examination with my approval as the university supervisor

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DEDICATION

I dedicate this research project to my parents. To my dad, Gervasio, thank you for your motivation and encouragement to work hard in school and to trust in God. To my mum, Virginia, thank you for being a huge influence and your prayers that kept me going throughout my studies. Thank you to all my siblings for your tremendous support. Special dedication to Mrs. Sat, the former headteacher Breaburn Imani School who allowed leave during working hours to pursue this course.

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ABSTRACT

The purpose of this study was to determine the student cognitive style in relation to their academic achievement in mathematics. The objectives of the study were: a) to determine the Students' Cognitive style; b) to determine the differences in Students' Cognitive style among boys and girls; and c) to determine the relationship between Students' Cognitive style and mathematical achievement.

The results indicate that there is a difference in the manner in which learners perceive, organize and represent the incoming information. These different characteristics of learners influence how they will respond and function in situations of learning. The learners with difficulties in representing and documenting procedures find mathematics difficult.

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Cognitive style is composed of characteristics in individuals that influence how they respond and function in different situations. Cognitive style is a person's preferred and habitual approach to organizing and representing information (Riding & Rayner 1998). It refers to an individual's characteristic and relatively consistent way of processing incoming information of all types from the environment (Chinn & Ashcroft 1993).

Cognitive style is different from learning style in that learning style is simply the application of an individual's cognitive style to a learning situation. (Schmeck, 1988). Learning style encompasses the learning environment, the medium, for example, auditory or visual, the structure of learning time and the characteristics of the learner. For example, the Numeracy Strategy gives a lesson structure that broadly splits into three sections, each with a different activity. Some learners will benefit from this sectional structure. The Numeracy Strategy also structures its programme so that topics are revisited at short time intervals. Again some learners will benefit from this built in revision/over learning structure. Others may find that they need more time to assimilate the information.

However, cognitive styles are concerned with how learners perceive incoming information, think, and solve problems as well as how they remember. For example, some learners prefer drawing pictures on a table; others would prefer to learn numbers and symbols. Some may prefer logical arguments and therefore they will always want

structured and closed kind of tasks. Other students would prefer open ended tasks that do not require a lot of precision.

It has been observed that teachers would prefer convergence where students document logically the procedure for arriving at a mathematical answer. This means that his teaching in a classroom setting is inclined towards a preferred way of representing information where evidence of procedures is documented in a step-wise format. This means that learners with difficulties representing information in a convergent format will always find mathematics to be a difficult subject for them and therefore develop negative attitude and hatred for mathematics. This imperatively means, depending on the mode of organizing and representing information that a teacher emphasizes on, a certain category of students might struggle.

The modern designers of mathematics curricula across the world seem to be moving to some similar conclusions, one of which is that, curriculum must encourage flexible thinking. That the 21st century learner needs to learn the way he/ she understand.

However this has not been the case, there is evidence to suggest that, there is still over-reliance on teaching formulas and procedures and examination is based on these procedures. For example, in the United Kingdom, a maths provision report for 14-19 year olds noted that; 'Even Staff with good subject knowledge often had a restricted knowledge of teaching strategies', and , 'mathematics became an apparently endless series of algorithms for them, rather than a coherent and interconnected body of knowledge' (Ofsted Evaluation Report 2006).

It seems that this has been the case over the years. In 1971, Skemp observed that: '*The increasing effort that the student makes will inevitably use the only approach which he knows, memorizing. This produces a short term effect, but no long term retention. So, further progress comes to a standstill, with anxiety and low self-esteem'.*Wagenschein 1983 says that *"I experienced myself, how mathematics can be opened by one teacher and closed by another".*The lack of flexibility in teaching and learning of mathematics means the testing, assessment and scoring in mathematics is also limited to a set procedure and documentation of work which puts students with different cognitive style at a disadvantage yet they may have better ideas of solving problems.

Presumably teachers who understand leaners cognitive styles and implement them through flexible instruction and assessment will develop confident learners who possess the necessary mathematical number and reasoning skills. Good numbers skills without good mathematical reasoning and problem solving skills makes mechanical learners who lack the necessary mathematical competencies to solve problems, notwithstanding the importance problem solving as a fundamental philosophical basis for the study of mathematics. Chinn 2012, observes that, Formulas, procedures, and accurate and swift recall of facts will lead to a version of success in number work, but countries need problem solvers as well as computationally adept pupils (particularly when calculators and computers are readily available).

This study will look at the relationship between the cognitive styles in mathematics and the students' achievement in mathematics in year nine grade-their existence among boys and how they affect students learning and achievement in mathematics.

In conclusion, there is need to understand the complexities of different leaners in relation to how they perceive and understand mathematics for problem solving. It is imperative for all teachers to do this in order to create a learning environment that encourage success and confidence in mathematics.

1.2 Statement of the Problem

Over the years, studies have been done to establish the relationship between cognitive styles and academic achievement in different subjects. A study by Norlia Abd Aziz, T. Subahan Meerah et.al. (2006), showed that there is a significant relationship between students' cognitive styles and internal motivation with their academic achievement. Another study showed that students would score low grades if they fail to adapt to the way of teaching and learning in the universities (Baharin Abu, 2000).

Despite the effort to address the complexities of students in relation to their cognitive styles and academic achievement, many students continue to score low grades in different academic subjects. These students who have failed to achieve excellent results admit that their lack of knowledge about how they learn (their cognitive styles) influence their performance.

Continuing with this trend, that is, lack of knowledge on cognitive styles will continue to affect students' performance negatively and therefore never achieve their optimal success. Therefore this study will investigate the relationship between students' cognitive styles with their academic achievement in mathematics. It is hoped that this study will help students to improve their academic performance. In addition, awareness of the

importance of the interaction between these three elements (i.e. cognitive style, teaching pedagogy and study environment) among teachers and students can also help the educational institutions and teachers to embrace teaching methods and environments that are more appropriate to student's cognitive styles.

1.3 Purpose of the Study

The purpose of this study is to identify the students' cognitive styles and determine whether there exists a significant relationship between students' cognitive styles and their academic achievement in mathematics

1.4 Objectives of the Study

a) To determine the Students' Cognitive Style

b) To determine the differences in Students' Cognitive style among boys and girls

c) To determine the relationship between Students' Cognitive style mathematical achievement

1.5 Significance of the Study

Cognitive style defines how the individual prefers to organise and present information in this case mathematical facts and connections in view to solve a problem. The study of students' cognitive styles and their influence on student achievement will affect the development and implementation of both the curricula and instructional process. It will

help the policy makers and curriculum designers to develop a design of curriculum that addresses the cognitive needs of all learners. This will ensure that there is both quality and equality in the learning process.

In curriculum implementation it will help teachers understand the differences among students in relation to the way they think and therefore embrace pedagogy or approaches that enhances meaningful learning of mathematics by the students.

The study will also help the students to understand themselves in relation to their cognitive style and how they learn and therefore utilize this knowledge to improve their performance in mathematics.

1.6 Justification of the Study

There are quite a number of existing researches on cognitive styles and learning. However, there is no research on cognitive style and academic achievement in the Kenyan situation. This study looks at how different cognitive styles affects the achievement in mathematics in Kenyan secondary schools.

This study will add value to the existing knowledge of Inchworm and grasshopper thinking styles as it seeks to establish the existing differences in cognitive style among boys and girls, the extent of the presence of the cognitive styles in a single classroom and also how the two cognitive styles affect the achievement of learners in mathematics.

1.7 Key Terminologies

Cognitive Development: Cognitive development refers to the construction of a thought process that includes problem solving, remembering and the ability to make decisions from childhood up to the adulthood stage. This ability to learn, reason and analyze the fact that a process begins from infancy and progresses as the individual grows. It involves activities that are conscious intellectual like thinking and remembering. (Schacter, Daniel L. 2009).

Cognition: the process, by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used (Neisser, 1967). In science and mathematics, cognition is the mental processing that includes the attention of working memory, comprehending and producing language, calculating, reasoning, problem solving, and decision making. In cognitive psychology and cognitive engineering, cognition is typically assumed to be information processing in a participant's or operator's mind or brain (Blomberg 2011).

Assimilation: The process of taking in new information into our previously existing schemas is known as assimilation. The process is somewhat subjective, because we tend to modify experience or information somewhat to fit in with our preexisting beliefs. In the example above, seeing a dog and labeling it "dog" is an example of assimilating the animal into the child's dog schema.

Accommodation*:* The process of changing or altering our existing schemas in light of new information, a process known as accommodation. Accommodation involves altering existing schemas, or ideas, as a result of new information or new experiences. New schemas may also be developed during this process.

Equilibration: Piaget believed that all children try to strike a balance between assimilation and accommodation, which is achieved through a mechanism Piaget called equilibration. As children progress through the stages of cognitive development, it is important to maintain a balance between applying previous knowledge (assimilation) and changing behavior to account for new knowledge (accommodation). Equilibration helps explain how children are able to move from one stage of thought into the next.

Cognitive style: is a term used in cognitive psychology to describe the way individuals think, perceive and remember information.

Global level thinkers: are apt to take on poorly defined abstract problems.

Local thinkers: focus on well-defined problems, possibly losing sight of the larger issues.

Legislative thinkers: these are self-supporting people who choose to accomplish tasks independently

Executive thinkers: these tend to follow established rules and systems.

Judicial thinkers are commonly critical and test the validity of pre-established rules and systems

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In this chapter focuses on systematic review of some of the major related studies and literature that provide the context, evidence and argument that are relevant in achieving the research objectives. The researcher tries to identify, appraise, select and synthesize high quality research that support this research and are relevant to answering the research question. It is organized in such a manner that it begins by looking at the related studies in a summary format, secondly, critically examining the literature of the study on cognitive styles; that is, the concept, the background and features of cognitive styles, why study cognitive styles in mathematics, literature on all the research objectives, theoretical framework on development of cognitive styles as well as the Conceptual framework of the study.

2.2 Related Studies

The analytic cognitive style has been postulated to facilitate mathematics performance, as mathematical tasks typically require students to break up a problem into its various components and then impose structure on the problem-solving process before arriving at a solution (Buriel 1978; Witkin et al. 1977; Zazkis, Dubinsky, and Dautermann 1996). Evidence exists that an analytic style is beneficial for mathematics achievement. For example, Letteri (1980) investigated academic achievement between students of different cognitive profiles. He found that seventh and eighth grade students with a Type 1 profile, described as analytic, focused, narrow, complex, reflective, sharp and tolerant, significantly outperformed Type 3 profiles, who were described as global, non-focused,

broad, simple, impulsive, leveller and intolerant on a standardised mathematics test. A number of other studies have also found the cognitive style of field independence is related to significantly better performance on tests of mathematics achievement (Abdollahpour, Kadivar, and Abdollahi 2006; Roberge and Flexer 1983; Vaidya and Chansky 1980). The field independent style is similar to Riding and Cheema's "analytic" cognitive style (Rayner and Riding 1997).

Study by Ramlah Jantan and Md. Nasir Masran (2007) try to find the relationship between teachers' teaching style and students' cognitive style with students' Mathematic achievement among primary school students. Participants of study consisted of 395 students (standard 3-6) with their 13 Mathematic teachers from selected schools in Perak and Selangor (Malaysia). GEFT (Group Embedded Figures Test) was used to identify students cognitive style either field-dependent (FD) or field-independent (FI) whereas 'Teaching Style Inventory' adapted from Grasha (1996) was used to identify teachers' teaching styles. The study found that there was positive and significant correlation between teachers' teaching style and students' cognitive style with their mathematic achievement. Coefficient correlation showed that the effect of teachers' teaching had greater influence than students' cognitive styles on their mathematic achievement.

Poh Bee Theen and Melissa Ng Lee Yen Abdullah (2008) try to determine the effect of gender, ethnicity and cognitive styles on achievement of form six students in General Paper. The sample comprised of 152 upper six students (60 boys and 92 girls) from a selected school in Perak. The GEFT test (Group Embedded Figures Test) was used to

measure students' cognitive styles. Finding showed that 69 (45.39%) students were from field-dependent cognitive style and 83 (54.61%) students were from field-independent cognitive style. Result of t-test revealed that girls' achievement was significantly higher than boys. Result of ANOVA showed that Chinese students score significantly higher than Malays and Indians. Finding showed that there were positive correlation between students' cognitive style and achievement in General paper.

Zhang and Sternberg (2002) study on thinking styles of Hong Kong and Chinese students found that the difference between females and males is significant in thinking style inventory so that male and female students are different in legislative, judicative, general, free and internal thinking styles, and in all cases males' scores are higher than females'.

2.3 Related Literature

2.3.1 The Concept of Cognitive Style
2.3.1.1 The background of the Cognitive Style Model

The first experimental studies revealing the existence of individual differences in simple cognitive tasks involving perception and categorization were conducted in the 1940s and early 1950s (Hanfmann, 1941; Klein & Schlesinger, 1951; Witkin, 1950; Witkin & Ash, 1948). Hanfmann (1941) showed that some individuals used a perceptual approach when grouping blocks whereas others used a more conceptual approach, trying first to formulate hypotheses about possible groupings. Witkin and Ash (1948) reported significant individual differences in the way people perceive the "upright" orientation of a rod in different surrounding fields in a task called the Rod-and-Frame Test. Witkin and

Ash found that some subjects perceived the rod as upright only when it was aligned with the axes of the field whereas other subjects were not influenced by the field characteristics. Klein (1951) studied how accurately people made judgments about changes in perceptual stimuli. Subjects received projected squares that constantly changed in size. Klein identified two types of individuals: *sharpeners,* who noticed contrasts and maintained a high degree of stimulus differentiation; and *levelers,* who noticed similarities among stimuli and ignored differences. The main contribution of these early studies was to identify robust individual differences in the performance of simple cognitive tasks and to demonstrate that people differed in their overall success and in the ways in which they perceived and solved the tasks. At that time, there was no established label for these individual differences; they were called perceptual attitudes, patterns, predispositions, cognitive attitudes, modes of responses, or cognitive system principles (Gardner, Holzman, Klein, Linton, &Spence, 1959.)

The notion of cognitive style was introduced by Klein and Schlesinger (1951) and Klein (1951), who were interested in possible between individual differences in perception and personality. Klein (1951) was the first to consider cognitive styles (he called them "perceptual attitudes") as patterns of adaptation to the external world that regulate an individual's cognitive functioning. "Perceptual attitudes are special ways, distinctive for the person, for coming to grips with reality" (p. 349). According to Klein, the process of adaptation requires balancing inner needs with the outer requirements of the environment. To achieve this equilibrium, an individual develops special mechanisms that constitute his or her "ego control system" (Klein, 1951, p. 330). Cognitive style expresses "a central

or executive directive of the ego-control system . . . and it acts very much as 'a selective valve' which regulates intake – i.e. what is or not to be ignored" (Klein, 1951, p. 333). Klein considered both poles of the leveling–sharpening dimension as equally functional (i.e., each pole is a means for individuals to achieve a satisfactory equilibrium between their inner needs and outer requirements). In leveling, the purpose is the obliteration of differences; in sharpening, it is a heightened sensitivity to them. Several years later, Holzman and Klein (1954) defined cognitive styles as "generic regulatory principles" or "preferred forms of cognitive regulation" in the sense that they are an "organism's typical means of resolving adaptive requirements posed by certain types of cognitive problems"

Witkin et al. (1954) conducted a large experimental study that played a crucial role in the further development of cognitive style research. The goal of Witkin's study was to investigate individual differences in perception and to associate these differences with particular personality tendencies. In Witkin's study, subjects received a number of orientation tests aimed at examining their perceptual skills, such as the Rod-and-Frame Test, in which subjects determined the upright position of a rod; the Body Adjustment Test, in which subjects judged their body position in different fields (e.g., defining their body position in rooms with tilted wall sand chairs); and the Rotating Room Test, in which subjects adjusted room to the true vertical position. In addition, subjects received the Embedded Figure Test, in which they identified simple figures in a complex one. Witkin et al. used a broad-spectrum of methods to examine the personality characteristics of their subjects, including autobiographical reports, clinical interviews, projective tests, and personality questionnaires. Witkin etal.'s main finding was that individual

differences in how people performed the perceptual tasks were stable over time and across tasks. Two groups of subjects were identified: *field dependent* (FD)—those who exhibited high dependency on the surrounding field; and *field independent* (FI)—those who exhibited low dependency on the field. It is worth mentioning that they found a large intermediate group of subjects who did not fall into either category

Other early studies were conducted by Witkin, Hertzman, Machover, Meissner, and Wapner (1954); Witkin, Dyk, Patterson, Goodenough, and Karp (1962). These and other studies resulted in theories that generally assumed a single dimension of cognitive style, with an individual's style falling somewhere on a continuum between the extremes of this dimension.

2.3.1.2 Identification of the main features of cognitive style

Along with Field Independence-dependence, many other cognitive styles have commonly been studied. Ridding and Cheema (1991), point out that many may be different names for the same personality dimension. Some of these include:

a) Field Dependence – Independence

A measure of field dependence is one of the most researched cognitive styles to date (Witkin &Goodenough, 1981) and was initially proposed by Witkin in the 1950's and 1960's and with educational implications by Witkin, Moore, Goodenough, and Cox in 1977.

The *Embedded-Figures Test* determines a subject's field dependence/independence based on the time they take to find a simple figure in a more complex visual field (see Witkin et al., 1977 for examples). Subjects who were field dependent spent more time finding the figure while field-Independent subjects found the figure quickly. Most people fell on a continuum between being completely field dependent or field independent.

b) **Holists-Serialistic**

The holistic – serialistic cognitive style was researched by Pask in the early 1970's. He tested a group of children by asking them to categorize a selection of imaginary animals into groups. He found that some children tend to try to understand the overall principles and will develop and test multiple hypotheses at one time; these subjects were holists or comprehension learners. By contrasts, serialists, or operation learners, proceeded with one hypothesis at a time and did not move on until that was tested. Serialsist tended not to think about a larger global view of the problem (Pask, 1976).

c) **Deep-level/Surface-level Processing**

Similar to the holist – serialists distinction is Marton and Säljö's deep-level/surface-level cognitive style research. Level of processing involves how a student (Marton and Säljö used undergraduates) approaches material for learning.

Surface-level students focused their learning on what Marton and Säljö call the sign, or the literal rote learning of given material. Other students, the deep-level processors, focused on what is signified rather than the sign itself, these students attempted to learn the intended meaning of the material. According to their study, surface-level processors tended to say things like, "I just concentrated on trying to remember as much as

possible," while the deep-level processors said that they tried to determine "what was the point of the article (Marton & Säljö, 1976, 5 - 6)

Deep-level processors, like holists, tended to quickly grasp the overall concepts and were normally intrinsically motivated but could sometimes miss the details (globetrotting). Likewise, surface-level processors, like serialists, concentrated on the details, required extrinsic motivation, and could sometimes miss the global view of a problem (improvidence). However, both deep and surface-level processing are required to develop a complete understanding of a topic (Ford, 2000), the distinction lies in the way material is initially approached.

d) Convergent- Divergent styles

Hudson (1968) identifies Convergent and Divergent cognitive styles. He suggests that convergent thinkers prefer formal materials and logical arguments. They may be superior in performance to divergent thinkers on tasks which are well structured and demand logical ability while divergent thinkers presumably are better in the more opened tasks than convergent thinkers. Guilford (1967) suggested that generating logical necessities is the critical feature of convergers, whereas generating the possibilities from the given information is the characteristic of divergers.

e) Quantitative and Qualitative styles

Sharma (1986, 1989) identified and labeled two extreme styles (personalities) as quantitative and qualitative. The characteristics of a quantitative style are essentially

sequential/ logical and those of the qualitative style are intuitive and holistic. Sharma also suggested that most personalities lie on a continuum between these two extremes. He calls the learning personalities. According to Sharma, qualitative learner approaches problems holistically and is good at spotting patterns. He uses an intuitive approach, tends not to show his working and does not like practice exercises. In contrast, he observes that quantitative learner processes information sequentially, looking for formulae, methods and recipes. This learner attempts to classify problems into types and to identify a suitable process to use in solving the problem

It is worth noting that intuitive style is not always viewed favourably. For example Skemp (1971) considered it a hit- and- miss method, which is not always reproducible.

Despite the different names by different researchers, research on basic cognitive styles clearly established robust differences in the way that individuals approached cognitive tasks. Cognitive styles research represents relatively stable individual differences- ways of organizing and processing information that cut across the personality and cognitive characteristics of an individual. Messick (1976) reviewed the literature of that period came to the conclusion that cognitive styles represent:

'Consistent individual differences in preferred ways of organizing and processing information and experience . . . . They are not simple habits . . . they develop slowly and experientially and do not appear to be easily modified by specific tuition or training . . . . The stability and pervasiveness of cognitive styles across diverse spheres of behaviour

suggest deeper roots in personality structure than might at first glance be implied by the

concept of characteristic modes of cognition.'

These theories can be linked with those of left-brain/right-brain thinking, which follow the same bipolarity pattern. Brain research in the late 1960s and early 1970s resulted in the discovery that the two sides of the brain are responsible for different mental functions (Buzan, 1983). Taking brain theory one step further and linking it to the concept of cognitive style, Wonder and Donovan (1984, p. 3) state, "Because of our specific genetic inheritance, our family life, and our early training, most of us prefer to use one side of the brain more than the other." The types of behaviors associated with the two sides are as follows (Wonder & Donovan, 1984):

- *Left brain*: analytical, linear, sequential, concrete, rational, and goal oriented; and

- *Right brain*: intuitive, spontaneous, holistic, symbolic, emotional, and visual.

- A review of the material on both cognitive style and left-brain/right-brain theory resulted in the following generalizations about cognitive styles:

- There are distinct, observable, and measurable differences among people's cognitive styles.

- Cognitive style can easily be detected through language and nonverbal behavior patterns. Dialogue between individuals can reveal differences and can highlight the need for awareness and understanding of these differences.

- Styles are frequently associated with career choices; therefore, there are connections between behavioral styles and certain functions or divisions within an organization. In fact, style can dominate an organization's culture.

- Styles take on connotations of "good" or "bad," with one style generally considered being "better" or "best" depending on the individual interpreter or system evaluator.

- There is a need to understand, recognize, and develop each area of cognitive specialty.

- Creativity and effectiveness can be increased when the bipolar dimensions are fused.

2.3.1.3 Philosophical basis for the study of mathematics

Philosophy of mathematics, as it was elaborated by Ross D.S. (2003), is a philosophical study of the concepts and methods of mathematics. According to him, philosophy of mathematics is concerned with the nature of numbers, geometric objects, and other mathematical concepts; it is concerned with their cognitive origins and with their application to reality.

The National Council of Teachers of Mathematics, NCTM standards (1989) provide specific foundation as to why we study mathematics. It provides seven assessment standards that focus on the assessment of students' understanding of and disposition towards mathematics. These are:

- Mathematical Power. This standard focuses on the integration of the abilities covered in other assessment standards. It focuses on the extent to which students (a) have integrated the information they have learned, (b) can apply what they've learned to problem situations, (c) can communicate their ideas, (d) have confidence in doing mathematics, and (e) value mathematics.

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- Problem Solving. Students should be assessed on their ability to use mathematics to solve problems.

- Communication. Assessment of students' ability to communicate mathematically should focus on both the meanings student attach to concepts and procedures, and to their fluency in talking about, understanding and evaluating ideas expressed through mathematics.

- Reasoning. Assessment techniques should specifically assess students' ability to use various types of reasoning that are fundamental to mathematics (e.g deductive or proportionate reasoning)

- Mathematical Concepts. Assessments of students knowledge should examine their understanding of mathematical concepts

- Mathematical procedures. Assessment of students' knowledge of procedures should determine not only whether students can execute procedures, but also whether they know the underlying concepts, when to apply the procedures, why the procedures work, and how to verify that the procedures yield correct answers.

- Mathematical disposition. Assessment should seek information about students' attitudes toward mathematics, including confidence, willingness to explore alternatives, perseverance and interest.

2.3.2 Cognitive Style and Mathematics

Cognitive style has been found to influence mathematics learning. The 21st century requires world-class problem solving personnel in mathematics and science. However, mathematics is a difficult subject to learn among the Kenyan students. Secondary school

students are afraid and have negative thought about Mathematics because it is difficult to understand and master (Ng See Ngean (1992). In his study, he found that 50% of the secondary school students hated mathematics because it is difficult and unattractive. One reason for the failure of students in mathematics other than intelligence and motivation were their cognitive styles (Kim 1999). Students' cognitive styles which do not match with teaching method can lead to students failing (Witkin and Goodenough, 1977; Norlia Abdul Aziz and colleagues, in 2006, John Males and colleagues, 2007).

 Bath (1984) and Bath et al. (1986) identifies two extreme thinking styles which affect the way students learn mathematics. They identify *Inchworm and Grasshopper* cognitive styles.

Chinn (2012) describes Grasshoppers are holistic, intuitive and resist documenting methods while inchworms are formulaic, procedural, and sequential and need to document. The characteristics of the grasshopper and Inchworm are summarized on the table below: Chinn (2012)

	INCHWORM	GRASSHOPPER
First approach to a problem	1. Focuses on the parts and details 2. Looks at the numbers and facts to select a suitable formula	1. Overviews, holistic, puts together 2. Looks at the numbers and facts to estimate an answer or narrow down the range of answers. This is controlled exploration not guessing.
Solving the problem	3. Formula, procedure oriented. 4. Constrained focus. Uses one method 5. Works in serially ordered steps, usually forward. 6. Uses numbers exactly as given 7. More comfortable with paper and pen. Documents method	3. Answer oriented 4. Flexible focus. Uses a range of methods 5. Often works back from a trial answer 6. Adjusts, breaks down/builds up numbers to make an easier calculation 7. Rarely documents method. Performs calculations mentally (and intuitively)
Checking and Evaluating answers	8. Unlikely to check or evaluate answers. If a check is done it will be by the same procedure/method 9. Often does not understand procedures or values of numbers. Works mechanically.	8. Likely to appraise and evaluate answer against original estimate. Check by an alternative method/procedure 9. Good understanding of number, methods and relationships.

The above characteristics are supported by Sharma (1986, 1989) who observes two personalities of an individual as quantitative and qualitative. Quantitative personality (style) is usually logical and sequential while qualitative style approaches problems holistically and intuitively. The sequential/logical approach in quantitative style is similar to Inchworm because they are always looking for formulae, methods and recipes while qualitative learning personality is similar to grasshopper cognitive style.

The cognitive style can also be viewed from a behaviourist and constructivist point. Bush (2006) describes behaviourists tenets as:

- teacher centered,

- focuses on developing skills,

- Learning as a solitary activity,

- Teacher provides sequence of steps,

- Assessment is primarily through testing

- Mastery of skills prior to their application,

- Individualised drill and rehearsal activities for mastery (Emphasis on short-term memorization)

- Strict adherence to fixed curriculum

Bush (2006) then identifies the characteristics of Constructivists as:

- Learner-centered

- Focus on deeper level of understanding

- Evolvement of a variety of materials and activities

- Teacher encourages discussions

- Emphasis is on discovering and constructing knowledge

- Students interact with materials to develop conceptual learning

- Students assimilate new concepts into prior knowledge

- Assessment is interwoven with teaching

The behaviourists characteristics resemble those of an Inchworm while the Constructivist tenets support the grasshopper cognitive style.

One of the issues that emerge from Chinn's Inchworms and grasshoppers do not think the same way. They have different ways in which they process, organize and present information. It also emerges that not all students fall in either category (Inchworm or grasshopper). Some will fall in the middle and they can apply either style in different mathematical problem situations. The children at the extreme ends are seen to be rigid into their ways of working. However, it is imperative that if these styles are identified, it will aid the teachers of mathematics use different ways of teaching and the students will be left to select the most suitable for them. This practically attractive and hence motivate them to learn mathematics.

Study by Alamolhodaei, (1996) found that various aspects of calculus tasks demands different dimensions of cognitive style on the part of learners. He found that calculus demanded more divergent thinkers (similar to grasshopper style) characteristics and therefore they scored higher in calculus than the convergent (similar to Inchworm style).

Therefore it may be reasonable to say that even though the nature of mathematical tasks indicates that students with either Inchworm or grasshopper style can cope well with different mathematical tasks; grasshoppers are likely to perform higher in many aspects of problem solving because of their open nature in their approach. The ability of grasshoppers to overview, think intuitively, estimate answers and work backwards from a trial answer (Chinn 2012) gives them an edge in problem solving.

2.3.3 Cognitive Style and Gender

Men have traditionally been viewed as rational thinkers while intuition has been viewed as (Hayes, Allinson & Armstrong, 2004). did a research that confirmed this stereotype while Kirton (1989) disapproved the research suggesting that men may be more intuitive than women.

Sternberg (1995) addresses that thinking styles of women and men are different because specific styles may be encouraged and punished and men's scores in comparison with women's are higher in legislative and internal thinking styles and it is lower in judging style

With respect to the four one-dimensional models, the styles such as field independence, reflective style, divergent thinking style, and achieving approach that are located at one pole, often show positive contributions to various learning performances. Different studies suggest that thinking styles are correlated with creative process, problem solving, decision making, educational success as well as achievement, training methods and

educational evaluation and also different factors including culture, age, parenting style of parents, socioeconomic status and above all gender are effective on thinking style.

In a study by Witkin et. al (1971) on Field dependence and field independence, he noted that males tend to represent field independence as their cognitive style. The girls and women -compared with boys and men –tend to be more field dependent in all age groups and in different types of culture Miller (2001). Apparently more pronounced field dependence of women is explained as biological (specialization of women and men in their biological functions as a conservative or exploratory behavior) and social (type of upbringing of girls and expectations of normative behavior of women clearly contribute to the formation of field dependence behaviors) determinants. Voyer (1995) during his research couldn't find significant differences between males and females when participants were under 18 years old.

Field independence (FI) being manifested in the analyticity of cognitive images: the propensity to detail and differentiate their educational experience, while adhering to the relevant elements of the perceived material (Witkin 1976), these characteristics are similar to *grasshopper* cognitive style. In contrast, field-dependence learners rely on the organization of the field as a whole and retain a global perspective as they work through problems, typical characteristics of *inchworm* cognitive style.

Also research by Ramlah J.H (2014) reveals that among boys, 66.2% boys were from FD and 33.8% were from FI learning styles. Among girls, 82.3% were FD and 17.7% were FI. The findings showed that many of the students in these school especially girls were from field-dependent cognitive style.

Implication of this study showed that these students need more teacher guidance and coaching in learning especially in Mathematics.

The boys tend to have field-independent (FI). Cognitive styles compared to girls which were inclined to have field-dependent (FD) cognitive styles.

2.3.4 Cognitive Style and Academic Achievement

While there is some debate regarding individual differences in cognitive style, researchers in this area suggest that style and ability are different constructs that may be equally important in student learning and success (Kolb, 1984; Papanikolaou et al., 2006; Russel, 1999; Saade, He, & Kira, 2007; Sternberg, 1997). Interest in styles, according to Sternberg (1997), developed in response to the belief that ability provides only a portion of the explanation for individual differences in performance. It has been suggested that both thinking and learning style models, as presented by Sternberg and Kolb respectively, should be considered in school settings (Russel, 1999). Individual differences in cognitive style (i.e. thinking style) may be important in understanding the factors, aside from intelligence and ability that contribute to student success in different instructional environments.

Thinking styles have been studied in various educational settings and investigating different academic outcomes. Grigorenko and Sternberg (1997) suggest that thinking styles significantly add to abilities as a tool for predicting academic achievement. Specifically, results from a high school sample indicate that legislative and judicial styles were both significant predictors of achievement on analytical tasks and judicial and

executive styles predicted performance on creative tasks (judicial positively and executive negatively). Additional results from studies of secondary students' thinking styles also indicated a relationship between thinking style and student learning (Cano-Garcia & Hughes, 2000; Sternberg & Zhang, 2001) as well as domain specificity in the role of thinking styles and student learning (Russel, 1999).

Zhang & Sternberg, 1998) academic performance was significantly associated with specific thinking styles. Zhang and Sternberg (1998) found that the thinking styles of hierarchical, judicial, conservative, and global positively predicted academic performance among Hong Kong University students and legislative, liberal, local style negatively predicted academic performance. Supporting much of this research Zhang's (2001) study observed that hierarchic thinking styles positively contributed to academic performance and executive, divergent style negatively contributed to the prediction of academic performance in Hong Kong University students.

Study by Ramlah Jantan and Md. Nasir Masran (2007) tried to find the relationship between teachers' teaching style and students' cognitive style with students' Mathematic achievement among primary school students. The study found that there was positive and significant correlation between teachers' teaching style and students' cognitive style with their mathematic achievement. Coefficient correlation showed that the effect of teachers' teaching had greater influence than students' cognitive styles on their mathematic achievement.

However, research done by Azizi Yahya, Yusof Boon & Wan Zuraidah Wan Hamid (2002), tried to find the relationship between students' cognitive styles and their

academic achievement. Result of study showed that there was no correlation between cognitive styles and students' academic achievement (r = 0.0 and r = 0.2).

2.3.5 Relationship between Teachers' and Student's Cognitive Style

Chinn (2012) observes that teachers exhibit different thinking styles. He observes that teachers who are teach maths but are not necessarily maths specialists are more likely to insist on the formulaic method that they were taught in school. This practically means that even though many researches state that cognitive style is habitual, many pupils cognitive style is open to influence. Therefore teachers teach and encourage flexible cognitive approach to maths problems.

2.4 Theoretical Framework

2.4.1 Introduction

There are several theories that form the foundation of Cognitive Development. We will look at the Piaget Theory of Cognitive Development and The Neo Piagetian Theory of Cognitive Development.

2.4.2 Piaget theory of Cognitive Development

Piaget (1973) developed a systematic study of cognitive development in children. Through his work, Piaget (1973) showed that children think in considerably different ways than adults do. This did not mean that children thought at a less intelligent degree, or at a slower pace, they just thought differently when compared to adults. Piaget's work showed that children are born with a very basic genetically inherited mental structure

(schema) that evolves and is the foundation for all subsequent learning and knowledge. He saw cognitive development as a progressive reorganization of mental processes resulting from maturation and experience. Therefore Piaget defines Intelligence as adaptation of an organism to the environment which is controlled by the Schema (mental organizations) that the individual uses to represent the world and designate. Jean Piaget (1973) viewed intellectual growth as a process of *adaptation* (adjustment) to the world. This happens through; Assimilation (the process of using or transforming the environment so that it can be placed in preexisting cognitive structures), Accommodation (the process of changing cognitive structures in order to accept something from the environment). Both processes are used simultaneously and alternately throughout life and the balance between the two (applying previous knowledge (assimilation) and changing behavior to account for new knowledge (accommodation) is achieved through a process he called equilibrium (Piaget 1973).

Piaget (1973) identified the following stages of Cognitive development as discussed in the table below: At each stage, the child will acquire more complex motor skills and cognitive abilities.

Stage	Age	Description/ Key feature
Sensorimotor Stage	0-2 Years	During this stage senses, reflexes, and motor abilities develop rapidly. Intelligence is first displayed when reflex movements become more refined, such as when an infant will reach for a preferred toy, and will suck on a nipple and not a pacifier when hungry. Understanding of the world involves only perceptions and objects with which the infant has directly experienced. Actions discovered first by accident are repeated and applied to new situations to obtain the same results. *Key feature:* Object Permanence. This develops towards the end of the Sensory-motor stage. It is the understanding that objects continue to exist even though they cannot be seen or heard.
Preoperational stage	2-7 years	The child in the preoperational stage is not yet able to think logically. With the acquisition of language, the child is able to represent the world through mental images and symbols, but in this stage, these symbols depend on his own perception and his intuition. *Key feature:* Egocentrism. Although he is beginning to take greater interest in objects and people around him, he sees them from only one point of view: his own. This stage may be the age of curiosity; preschoolers are always questioning and investigating new things. Since they know the world only from their limited experience, they make up explanations when they don't have one. It is during the preoperational stage that children's thought differs the most from adult thoughts.
Concrete Operational	7-11 years	The stage of concrete operations begins when the child is able to perform mental operations. Piaget defines a mental operation as an interiorized action, an action performed in the mind. Mental operations permit the child to think about physical actions that he or she previously performed. The preoperational child could count from one to ten, but the actual understanding that one stands for one object only appears in the stage of concrete operations. This Stage is Characterized by: a) *Reversibility-* The child can mentally reverse the direction of his or her thought. A child knows that something that he can add, he can also subtract. He or she

		can trace her route to school and then follow it back home, or picture where she has left a toy without a haphazard exploration of the entire house. b) *Logic*- Children begin to use Inductive logic-This involve going from a specific experience to general. They however have difficulty using deductive logic. A child at this stage is able to do simple mathematical operations. Operations are labeled "concrete" because they apply only to those objects that are physically present. *Key feature:* Conservation-Piaget defines conservation as the ability to see that objects or quantities remain the same despite a change in their physical appearance. Children learn to conserve such quantities as number, substance (mass), area, weight, and volume; though they may not achieve all concepts at the same time.
Formal Operational Stage	11+ years	The child in the concrete operational stage deals with the present, the here and now; the child who can use formal operational thought can think about the future, the abstract, the hypothetical. Piaget's final stage coincides with the beginning of adolescence, and marks the start of abstract thought and deductive reasoning. Thought is more flexible, rational, and systematic. The individual can now conceive all the possible ways they can solve a problem, and can approach a problem from several points of view. The adolescent can think about thoughts and "operate on operations, not just concrete objects. He or she can think about such abstract concepts as space and time. The adolescent develops an inner value system and a sense of moral judgment. He or she now has the necessary "mental tools" for living his life *Key characteristics:* Multiple Ideas in the head such as-Abstract reasoning, use of deductive reasoning, Problem-solving

According to Piaget (1958), assimilation and accommodation require an active learner, not a passive one, because problem-solving skills cannot be taught, they must be discovered.

Within the classroom, learning should be student centred, accomplished through active discovery learning. The role of the teacher is to facilitate learning, rather than direct tuition. Therefore teachers should encourage the following within the classroom:

- Focus on the process of learning, rather than the end product of it.

- Using active methods that require rediscovering or reconstructing "truths".

- Using collaborative, as well as individual activities (so children can learn from each other).

- Devising situations that present useful problems, and create disequilibrium in the child.

- Evaluate the level of the child's development, so suitable tasks can be set.

Therefore this theory is explains the differences in different styles within the classroom.

2.4.3 Neo-Piagetian theories of cognitive development

Jean Piaget**'s** theory of cognitive development has been criticized on many grounds:

a) It is suggested that Piaget's theory does not explain why development from stage to stage occurs.

b) The theory ignores individual differences in cognitive development. It does not account for the fact that some individuals move from stage to stage faster than other individuals.

c) His theory is based on an unrepresentative sample of children

d) It underestimates the children's abilities

e) Research shows that the functioning of a person at a given age may be so variable from domain to domain, such as the understanding of social, mathematical, and spatial concepts, that it is not possible to place the person in a single stage.

2.4.3.1 The development and Structure of learning

To remove these weaknesses, a group of researchers, who are known as neo-Piagetian theorists, advanced models that integrate concepts from Piaget's theory with concepts from cognitive and differential psychology.

The neo-Piagetian theorists agree that there are two phenomena involved in determining the level of an individual's response to an environmental cue; (Biggs and Collis, 1991)

a) the *mode* of functioning which is determined by the level of abstraction of the elements utilized

b) the complexity of the *structure* of the response within that mode

These two together clearly form the basis for the theoretical stance taken by Biggs and Collis in the SOLO (Structure of the Observed Learning Outcome) taxonomy. (Biggs and Collis, 1991)
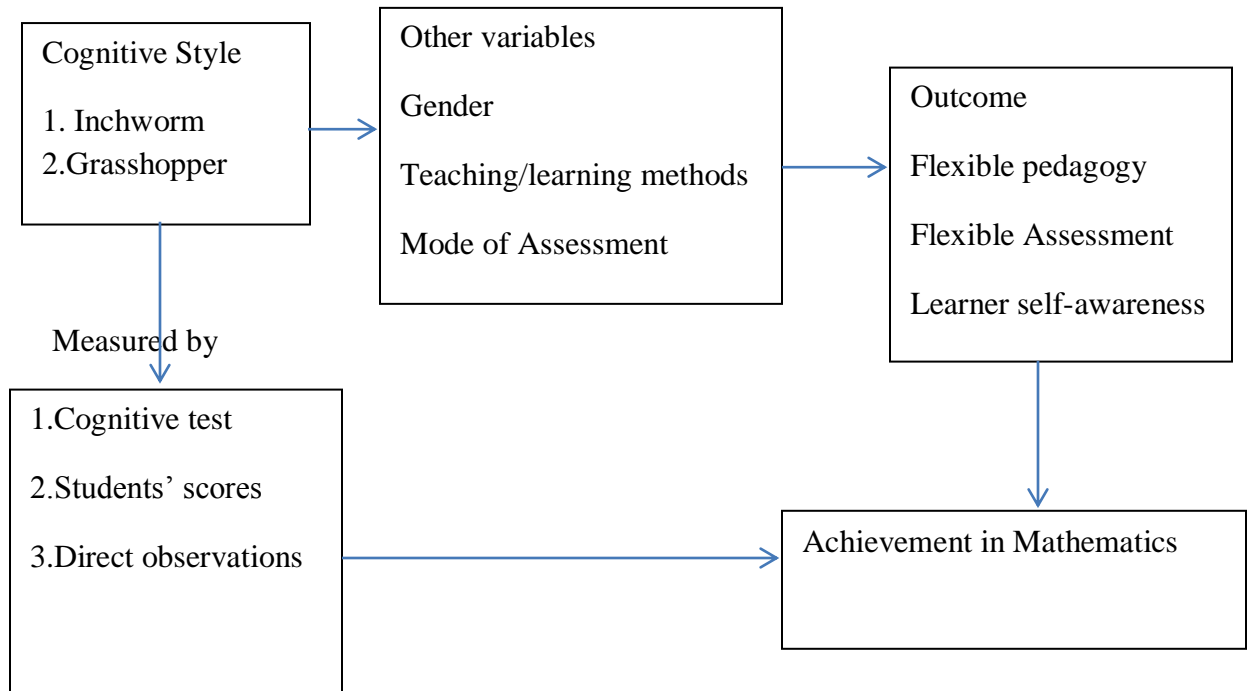
The modes progress from concrete actions to abstract concepts and principles and, in direct contrast to Piagetian theory, the emergence of one mode does not replace its predecessor. The modes in fact accrue, the later developing modes existing alongside the earlier modes.

The implication of this is twofold:

First, as the individual matures psychologically, the mode(s) developed earlier continue to develop on the basis of the increasingly mature physical and intellectual background; secondly, as the modal repertoire available increases, multimodal functioning becomes the norm.

The Neo Piagetian theory is very applicable in evaluating student's achievement in a mathematical topic. to assess the quality of student learning in mathematics-the teachers are able to assess the level of skill which the child has reached in the topic under consideration. If, for example, in addition we are interested in a child's ability to utilize intermodal functioning in solving mathematical problems (e.g., use of Ikonic or sensorimotor in conjunction with concrete symbolic or formal modes), then particular strategies for assessing this aspect would need to be employed. An overall evaluation of the child's performance could well take both aspects to account.

2.5 Conceptual Framework

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┌──────────────────┐      ┌─────────────────────────┐
│ Cognitive Style  │      │ Other variables         │
│                  │      │                         │         ┌──────────────────────────┐
│ 1. Inchworm      │ ───► │ Gender                  │         │ Outcome                  │
│ 2.Grasshopper    │      │                         │  ───►   │                          │
│                  │      │ Teaching/learning methods│        │ Flexible pedagogy        │
└──────────────────┘      │                         │         │                          │
         │                │ Mode of Assessment      │         │ Flexible Assessment      │
         │                └─────────────────────────┘         │                          │
         │                                                    │ Learner self-awareness   │
   Measured by                                                └──────────────────────────┘
         │                                                               │
         ▼                                                               │
┌──────────────────┐                                                     ▼
│ 1.Cognitive test │                                          ┌──────────────────────────┐
│                  │                                          │ Achievement in Mathematics│
│ 2.Students' scores│  ─────────────────────────────────►    │                          │
│                  │                                          └──────────────────────────┘
│ 3.Direct observations│
└──────────────────┘
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CHAPTER THREE: RESEARCH METHODOLOGY

3.1: Research Design

The study adopted a descriptive survey design which was used to collect information, record the information collected, analyze and report conditions that exist (Fraenkel and Wallen, 2008). Mugenda (2003) points out that descriptive survey research is research whereby participants answer questions administered through interviews, questionnaires or observation tests intended to produce statistical information about aspects that interest policy makers. In this study participants answered questions on an observation test worksheet based on mathematical cognitive styles. Descriptive survey design is suitable for collecting original data for the purpose of describing a population which is too large to observe directly like the secondary student population (Weirsma 2002).

3.2: Population and Sample

The population that was considered in the study consisted of Form 3 students. The sampling was done from selected secondary schools in Kenya.

3.3: Sample Selection

The sampling of schools was Purposive, two high achieving schools and two low achieving schools based on 2013 national exams mean scores were sampled. The sample size 158 participants (n = 158) was considered, 79 males and 79 female students from both categories of schools.

3.4 Instrument for Data Collection

The following instruments for data collection were administered:

a) Student Assessment tool. This instrument contained 13 items that the students worked out showing how they preferred to approach, organize and present logic of what they know

b) Respondents' Assessment tool. This instrument contained statements 'A, B, C, D' that allowed the students to select the possible method they used to work each question in instrument 'a' above. Option 'D' was chosen only when the students used any other method apart from the alternatives 'A, B and C' listed.

c) Student Self Analysis Response Sheet. This was used by the students to summarize their responses from instrument 'b' above.

The participant's first term and second term scores in mathematics were collected for and used in the analysis.

3.5 Validity

The Instrument that was used is a published instrument, thus it did not require the researcher's validation

3.6 Data Collection Preparation and Procedures

The data was collected according to the laid down procedures of data collection.

3.7 Data Analysis Procedures and Presentations.

.The data was coded as: one (1) standing for Inchworm characteristics, two (2) for intermediate tendencies, and three (3) for Grasshopper cognitive style. The data was then analyzed using the Statistical Package for Social Sciences (SPSS), applying descriptive and inferential statistics. These were presented using means, percentages, tables, charts and graphs.

CHAPTER FOUR: RESEARCH RESULTS

4.1 Introduction

The sample population for this study was 158 students drawn from four secondary schools in Nairobi area. According to table 1, of the 158 students, 41 were from Alliance Boys representing 25.9% of the sample size, 41 from Limuru Girls representing 25.9% of the sample population, 38 from Ruiru Boys representing 24.1% of the sample size and 38 from Ruiru Girls representing 24.1% of the total sample size. These were all valid percentages.

Table 1: Participants by school

Name of the School

		Frequency	Percent	Valid Percent	Cumulative Percent
	Name of school	Total	%		
Valid	School 1 (high)	41	25.9	25.9	25.9
	School 2 (low)	38	24.1	24.1	50.0
	School 3 (high)	41	25.9	25.9	75.9
	School 4 (low)	38	24.1	24.1	100.0
	Total	158	100.0	100.0	

The table below shows that there was 50% participation by each gender, boys and girls.

Table 2: Participants by Gender

Sex of the Student

		Frequency	Percent	Valid Percent	Cumulative Percent
	Sex of student	Total	%		
Valid	Boy	79	50.0	50.0	50.0
	Girl	79	50.0	50.0	100.0
	Total	158	100.0	100.0	

The table 3 below shows that there were 51.9% participants from high rank school and 48.1 % from low rank school. The High rank schools are schools that had a mean of 9 and above. School 1 (Boys) had a mean of 11.2, School 3 (Girls) 9.83. Low rank schools

are those that had a mean score of 6 and below. School 2 (boys) had a mean of 6.28 and School 4 (girls) scored 5.21. All the scores are based on 2013 Kenya Certificate of secondary education results.

**Table 3: Participants by school ranks**

Level of the School

		Frequency	Percent	Valid Percent	Cumulative Percent
	Level of school	Total	%		
Valid	High Rank school	82	51.9	51.9	51.9
	Low Rank school	76	48.1	48.1	100.0
	Total	158	100.0	100.0	

4.2 Objective One: To Identify the Students' Cognitive Style

Table 2.0 Overall cognitive styles

	Base Total	Name of the School				Sex of the Student		Level of the School		Mean score for Maths in term1 and term2	
		Sch1 Boys	Sch2 Boys	Sch3 Girls	Sch4 Girls	Boy	Girl	High Rank	Low Rank	Less or equal 50%	More than 50%
	158	41	38	41	38	79	79	82	76	114	44
Inchworm	75%	69%	76%	78%	77%	72%	78%	74%	76%	79%	64%
Intermediate	12%	14%	11%	10%	13%	13%	12%	12%	12%	12%	13%
Grasshopper	13%	17%	13%	11%	10%	15%	11%	14%	12%	9%	23%

Figure 1.1 Overall Cognitive Styles
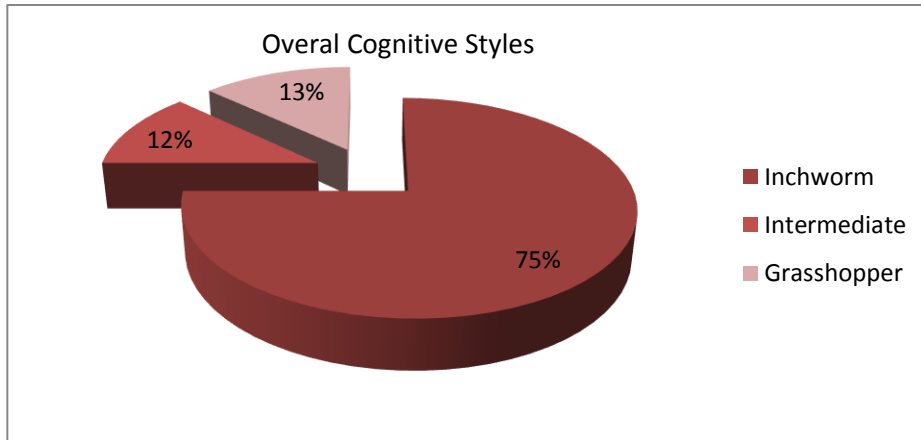
The Figure 1.1 above indicates that 119 students (75%) were from the Inchworm cognitive style, 19 students (12%) were of the Intermediate Cognitive Style and 20 students (13%) were from Grasshopper thinking style. This shows that more students from the sample leaned towards Inchworm thinking style.

Table 2.1 Cognitive style and level of school

	Base Total	Level of the School	
		High Rank	Low Rank
	158	82	76
Inchworm	75%	74%	76%
Intermediate	12%	12%	12%
Grasshopper	13%	14%	12%

Figure 1.2 Cognitive style and High Rank Schools
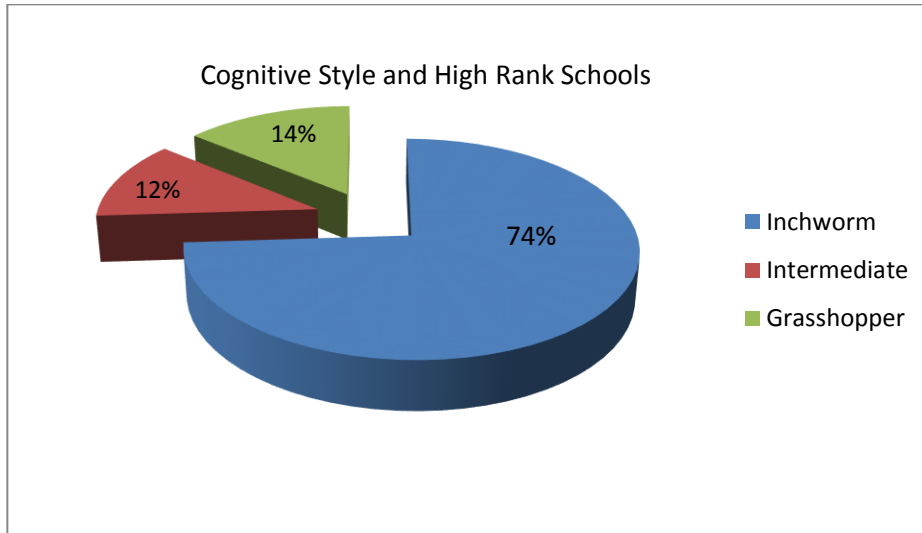
The Figure 1.2 above shows that 74% of the students from high rank school possessed Inchworm thinking style, 12% had Intermediate thinking style while 12% were Grasshoppers. Though the majorities were of inchworm thinking style, this percentage is less than the overall percentage of the Inchworms. The grasshoppers were also more (14%) than in high rank school than the overall grasshoppers (13%).

Figure 1.3 Cognitive Style and Low Rank Schools

Cognitive Style and Low Rank Schools

- Inchworm
- Intermediate
- Grasshopper
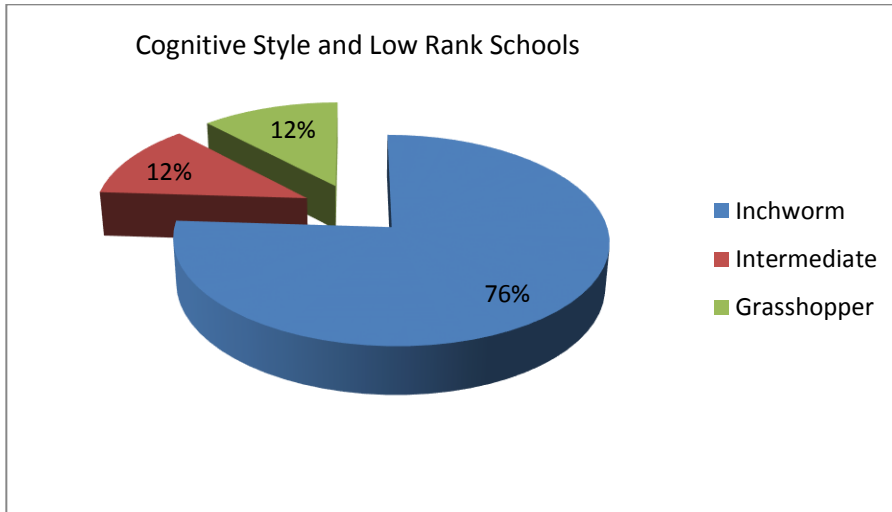
From the Low rank school, 76% of the students leaned towards Inchworm thinking style, 12% towards the Intermediate style and also 12 % towards the Grasshopper thinking style. The prevalence of students who tended to have Inchworm thinking style was higher than the overall percentage indicating that students from low rank schools tended to be more Inchworms than students from high rank schools.

Figure 1.4 Cognitive style and mathematical concepts
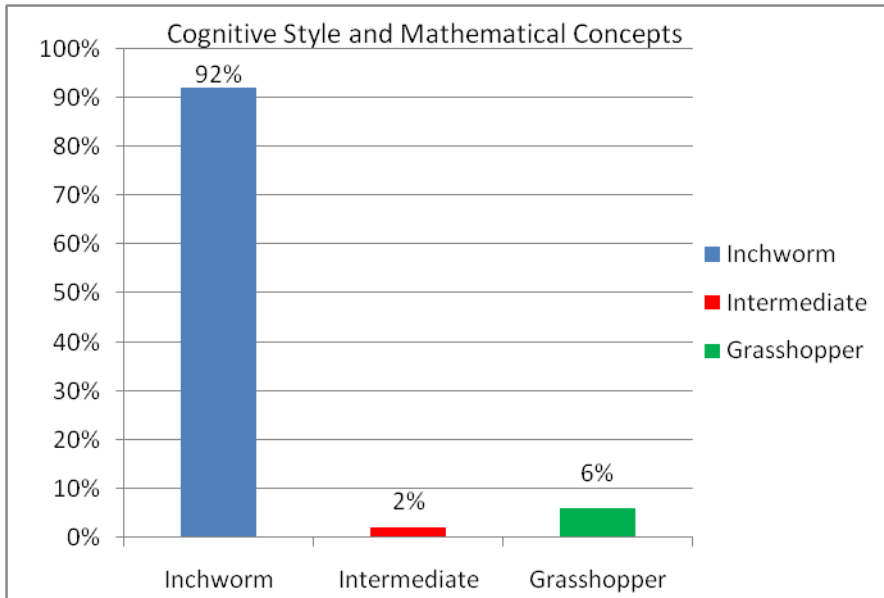
Figure 1.4 above indicates the prevalence of Cognitive style on mathematical concepts standard. It shows that 92% of the participants were from the Inchworm cognitive style, 2% were from intermediate and 6% were from grasshopper thinking style. This indicates that on Mathematical concepts, the majority of students favoured inchworm kind of thinking.

Figure 1.5 Cognitive Style and Maths Concepts in High Rank Schools
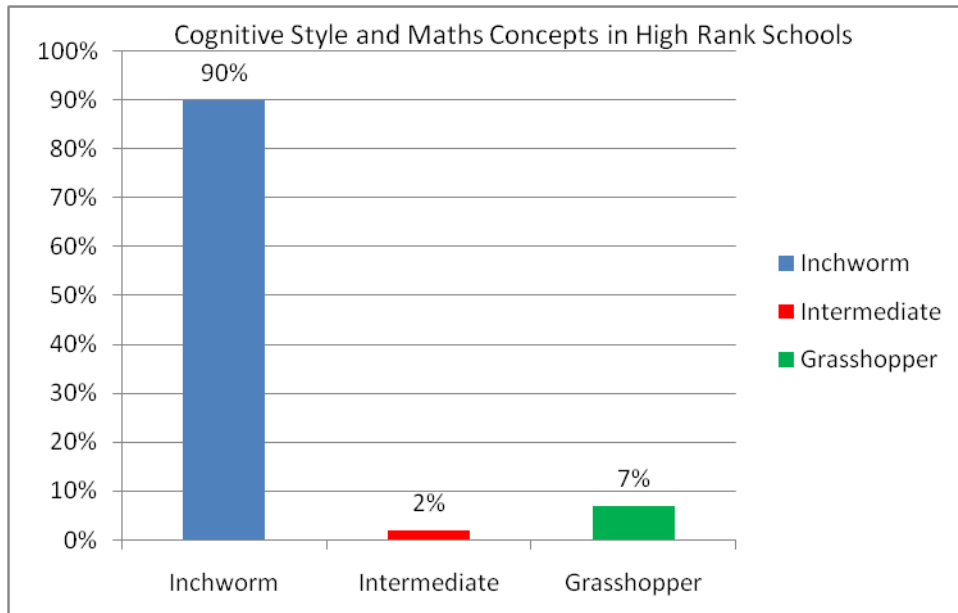
Figure 1.5 shows that 90% of students used Inchworm cognitive style when approaching maths concepts problems among the high ranking schools, 2% used Intermediate cognitive style and 7% used Grasshopper thinking style. This showed that Inchworm style was the most prevalent.

Figure 1.6 Cognitive Style and Maths Concepts in Low Rank Schools
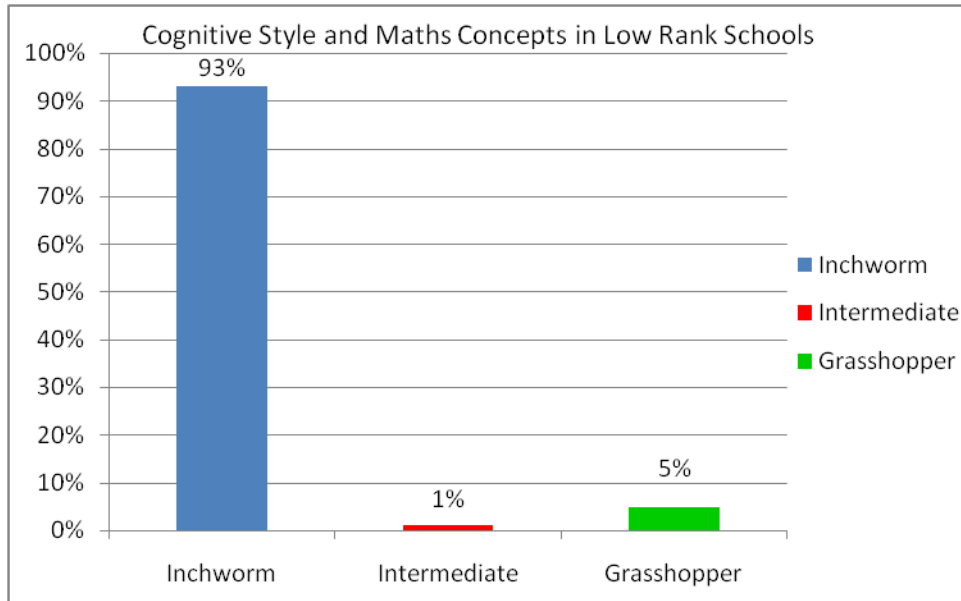
Table 1.6 indicates that, among the low rank schools, 93% of participants used Inchworm Cognitive style, 1% Intermediate style and 5% Grasshopper style when approaching maths concepts problems. More students used Inchworm style than in high rank school and less students used grasshopper style than in high rank schools.

Figure 1.7 Overall cognitive Style and Problem Solving in Schools
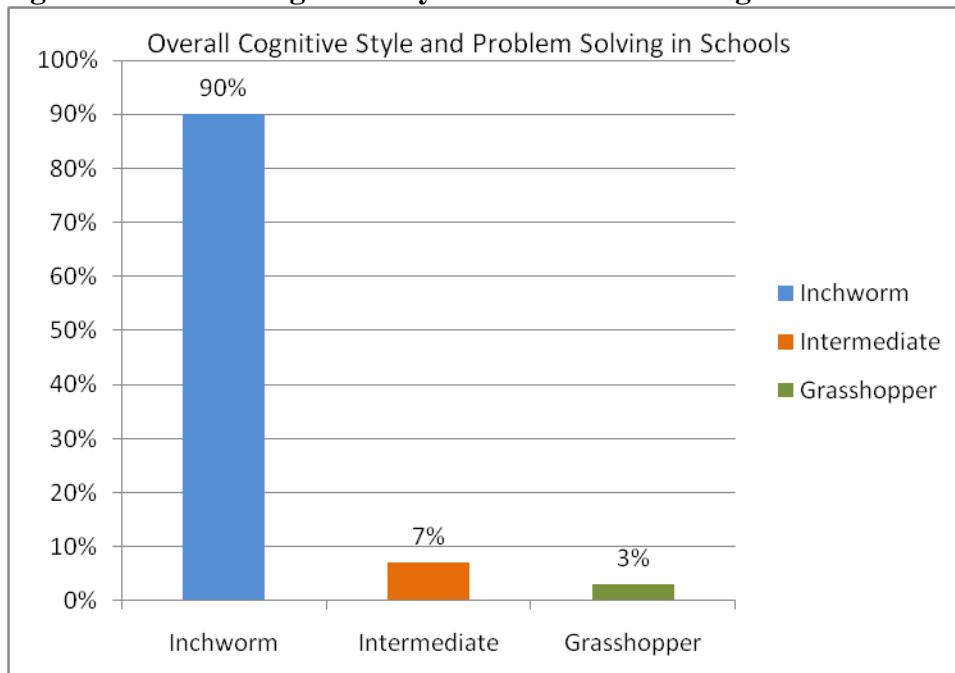
Figure 1.7 above reveals that in problem solving, 90% of the students preferred Inchworm thinking style, 7% intermediate thinking style, and 3% Grasshopper thinking style on the overall data.

Figure 1.8 Cognitive style and Problem Solving in High Rank School
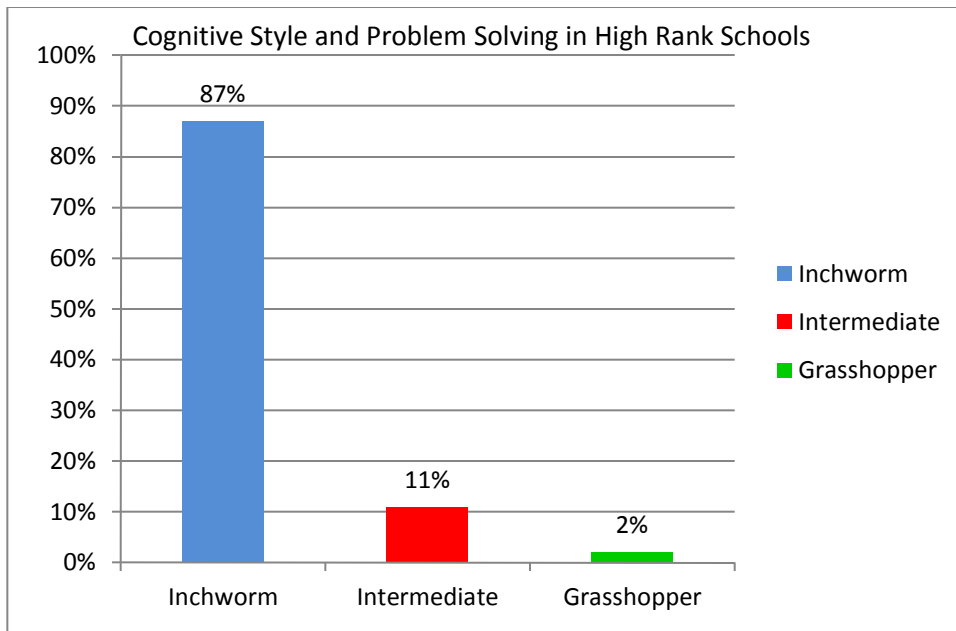
Figure 1.8 shows the relationship between the cognitive style and problem solving among the high rank schools. 87% tended to follow Inchworm style, 11% Intermediate style and only 2% used Grasshopper cognitive style.

Figure 1.9 Cognitive Styles and Problem Solving in Low Rank Schools
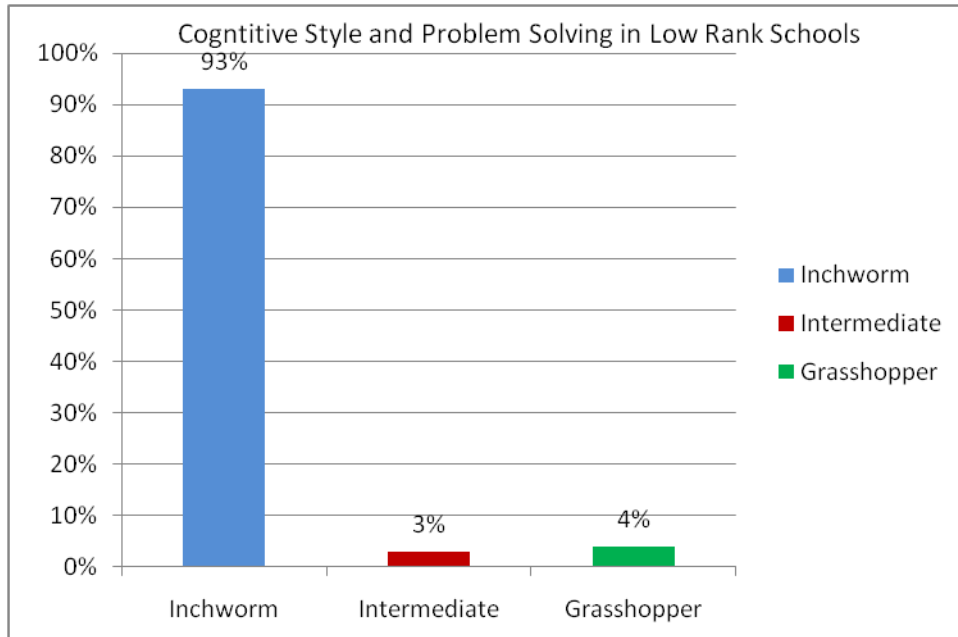
Figure 1.9 shows that, In Low rank schools, 93% (higher than in high rank schools) used Inchworm style to solve problems. 3% used intermediate strategies and 4% used grasshopper style. Interestingly there were more grasshoppers among the low rank schools than in high rank schools.

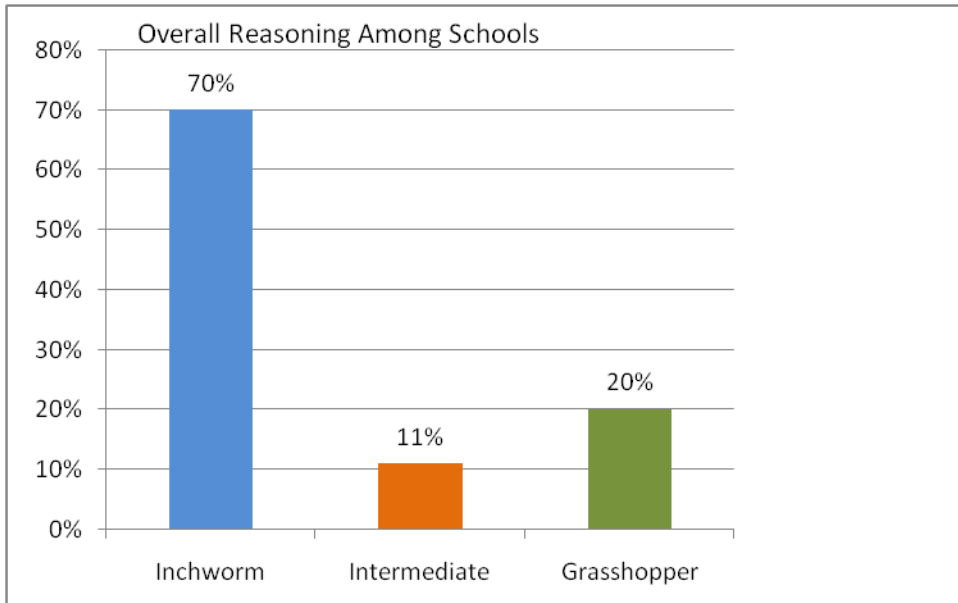**Figure 2.0 Overall Cognitive Style and Maths Reasoning In Schools**

Figure 2.0 shows that in reasoning, 70% of students preferred Inchworm cognitive style, 11% intermediate and 20% used Grasshopper style. This shows that there are more grasshoppers in reasoning than in the other mathematical standards.

Figure 2.1 Cognitive Styles and Maths Reasoning in High Rank Schools
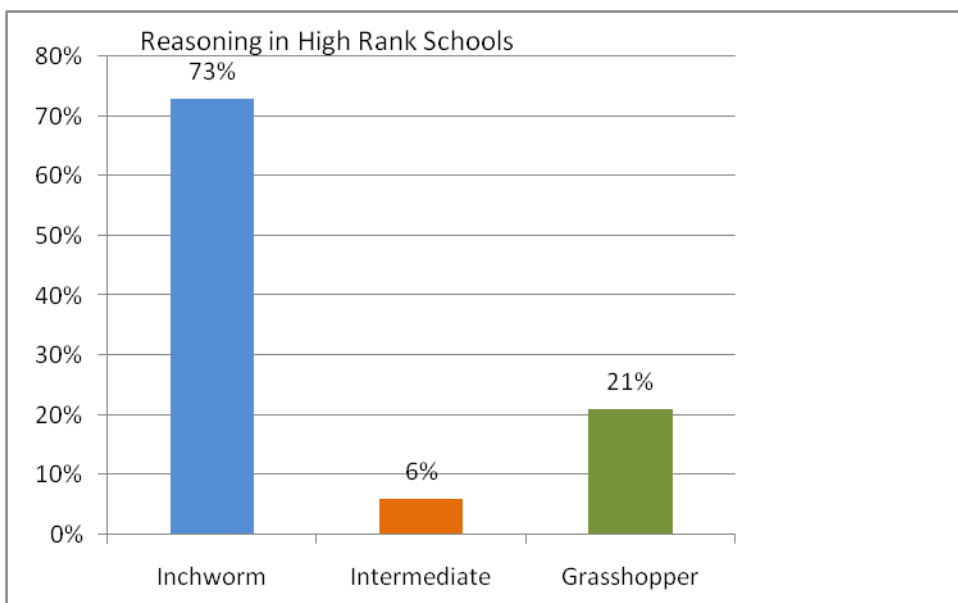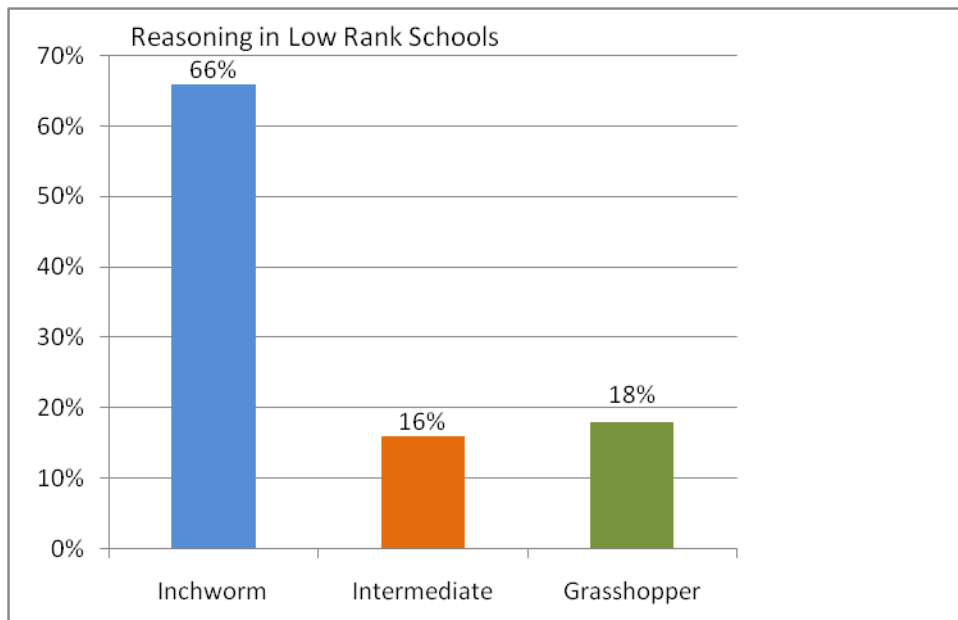
Figure 2.1 shows that among the high rank schools, a majority 73% of students applied Inchworm style, 6% used intermediate style and 21% tended to use Inchworm style. In reasoning the number of grasshoppers is higher.

Figure 2.2 Cognitive styles and Maths Reasoning in Low Rank Schools

In figure 2.2 above, a majority of 66% of the students showed preference to Inchworm reasoning. 16% and 18% used intermediate and Grasshopper style respectively.

In this data, there is less inchworm style students among the low rank schools compared to the high rank schools. However, the number of Grasshoppers is less.

Table 2.2 Result of T-Test Differences in Cognitive Styles Based on School rank

Congnitive Style	Rank of the school	Std. Error Difference	Degree of freedom	t-Value	Sig.
Mathematical Concepts	High rank	0.143	156	-0.156	0.982
	Low rank	0.143			
Problem Solving	High rank	0.172	156	-2.895	0.031
	Low rank	0.169			
Reasoning	High rank	0.143	156	-1.104	0.022
	Low rank	0.153			

Table 2.2 above reveal that there exist significant difference in cognitive style among the high rank and low rank school in problem solving and reasoning (p<0.05). However there was no significant difference in the mathematical concepts (p> 0.05).

4.3 Objective Two: To determine the differences in Students' Cognitive style across gender

Table 2.3 Gender differences on Cognitive style

	Base Total	Sex of the Student	
		Boy	Girl
	158	79	79
Inchworm	75%	72%	78%
Intermediate	12%	13%	12%
Grasshopper	13%	15%	11%

Figure 2.3 Cognitive Styles among Boys

Boys and Cognitive Style
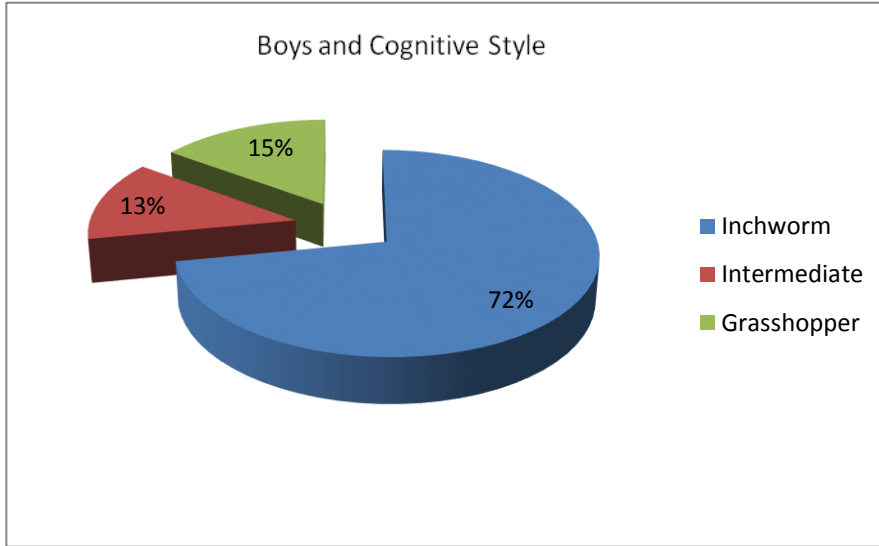
15%

13%

72%

- Inchworm
- Intermediate
- Grasshopper

Figure 2.3 shows that, among the boys, 72% were Inchworm thinkers, 13% were intermediate thinkers while 15 % were from grasshopper cognitive style.

Figure 2.4 Cognitive Styles among Girls

Girls and Cognitive Style

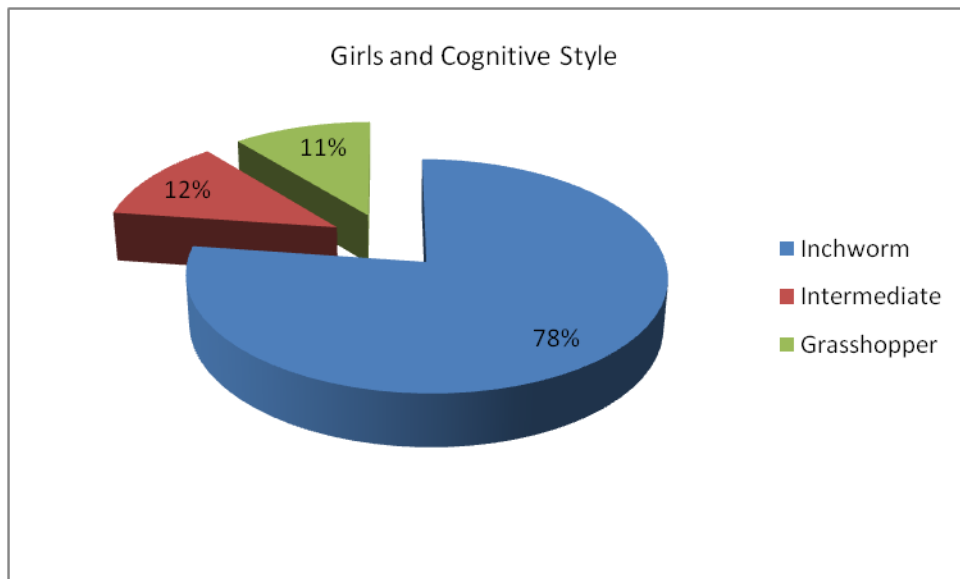11%

12%

78%

- Inchworm
- Intermediate
- Grasshopper

Figure 2.4 above shows that, among the girls, 78% were from Inchworm cognitive style, 12% from intermediate cognitive style and 11% tended to be grasshopper thinkers.

This information reveals that there were more Inchworm thinkers among the girls compared to the boys. There were also less grasshopper thinkers among the girls compared to the boys.

A further analysis of cognitive style among the gender in three different mathematical standards revealed the information below:

Figure 2.5 Cognitive Styles among Boys in Mathematical Concepts
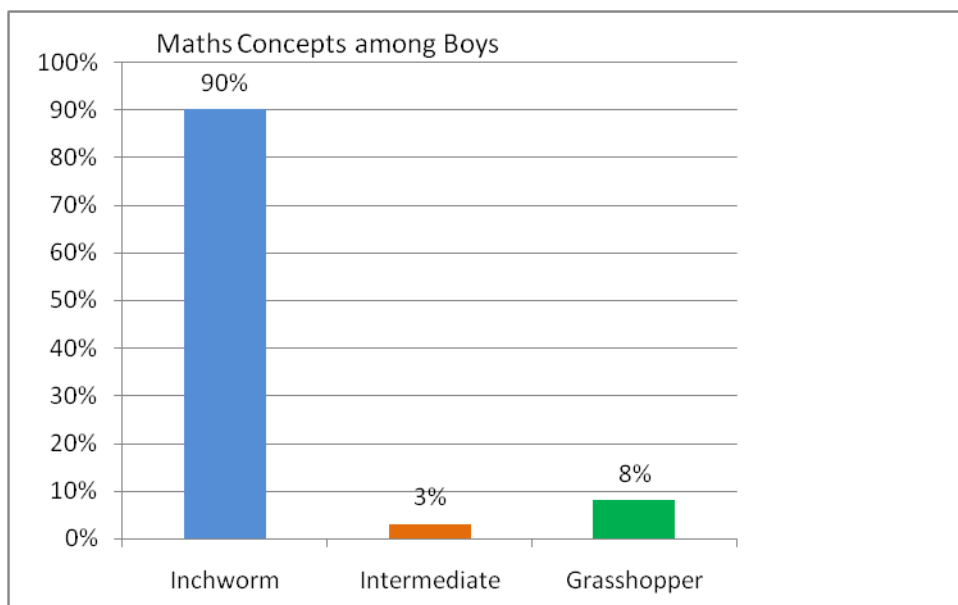

Figure 2.5 reveals that, in maths concepts, 90% of the boys showed inchworm cognitive style, 3% showed intermediate cognitive style and 8% were from grasshopper cognitive style.

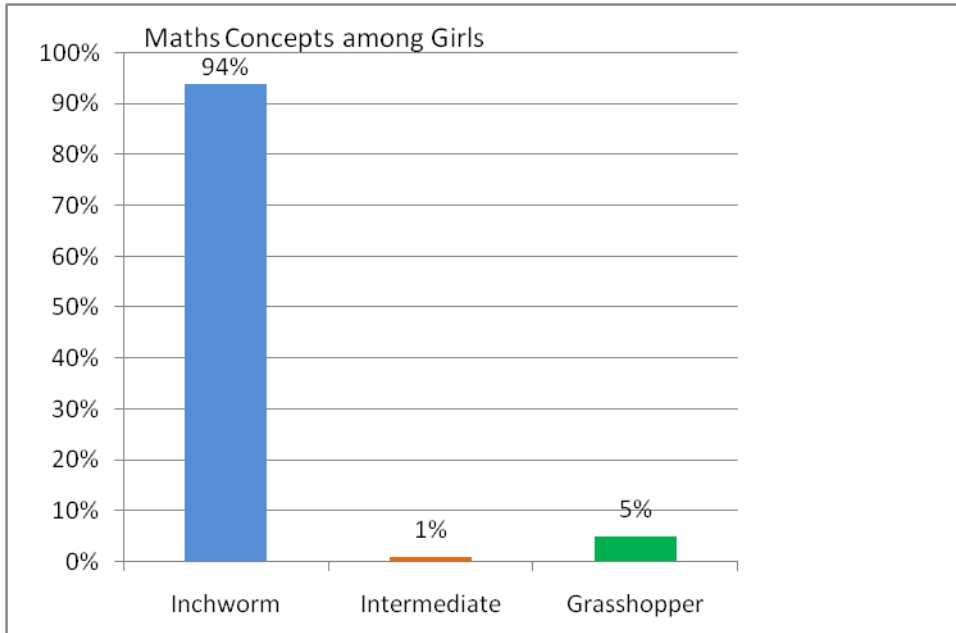**Figure 2.6 Cognitive Styles among Girls in Maths concepts**

Figure 2.6 shows that 94% of the girls demonstrated Inchworm thinking style, 1% intermediate thinking style and 5% showed grasshopper thinking style.

Therefore in maths concepts, there are more Inchworm girls compared to boys and there are more grasshopper boys compared to girls.

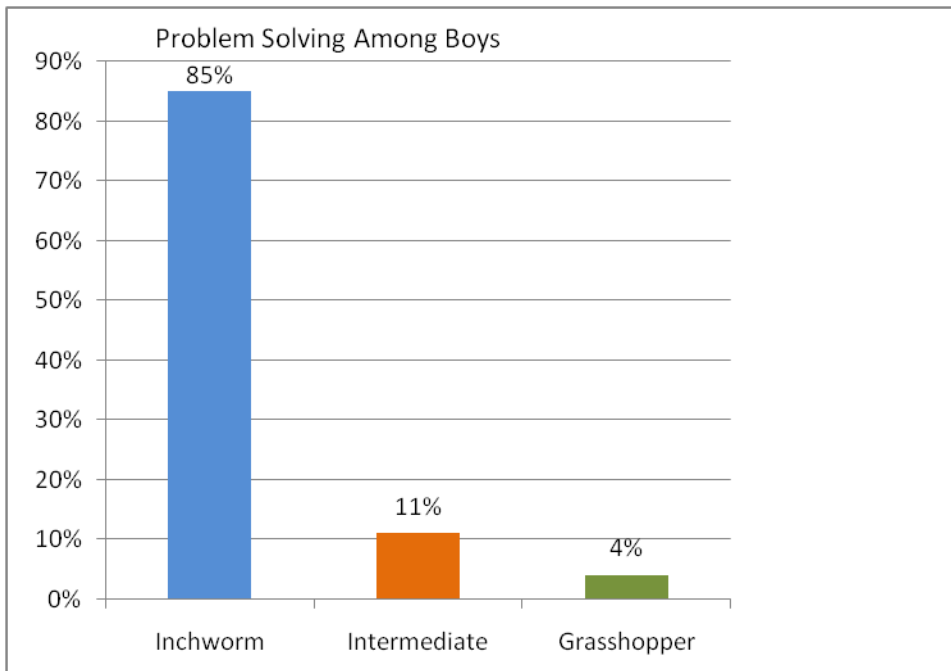**Figure 2.7 Cognitive Styles among Boys In Problem Solving**

Figure 2.7 shows that, in problem solving, 85% of the boys were from Inchworm cognitive style, 11% were from Intermediate cognitive style and 4% were from grasshopper cognitive style

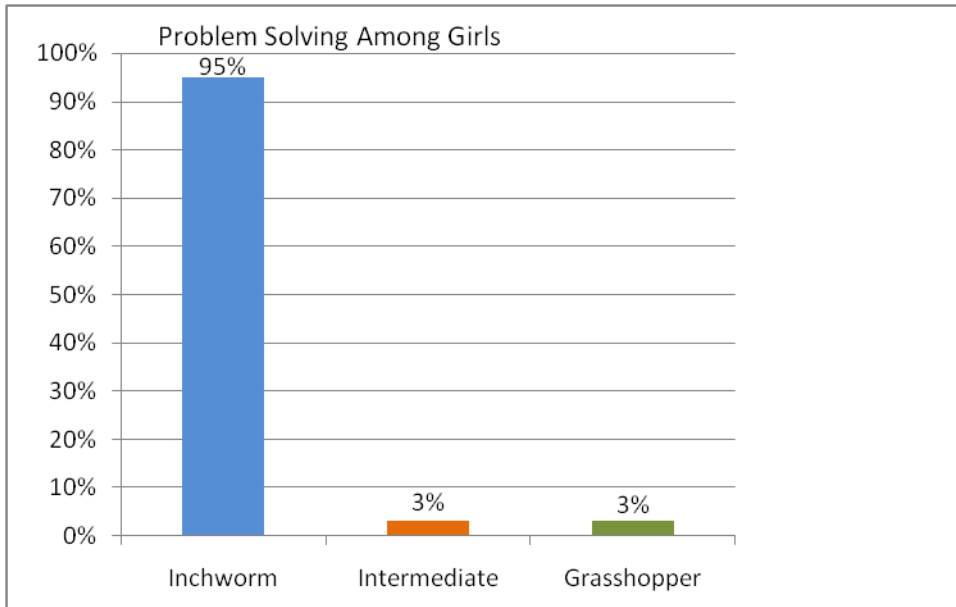**Figure 2.9 Cognitive Styles among Girls In Problem Solving**

Figure 2.9 shows that, in problem solving, 95% of the girls were from Inchworm cognitive style, 3% were from Intermediate cognitive style and another 3% from the grasshopper thinking style.

This indicates that there were more Inchworm girls compared to boys and also there were more grasshopper boys compared to girls.

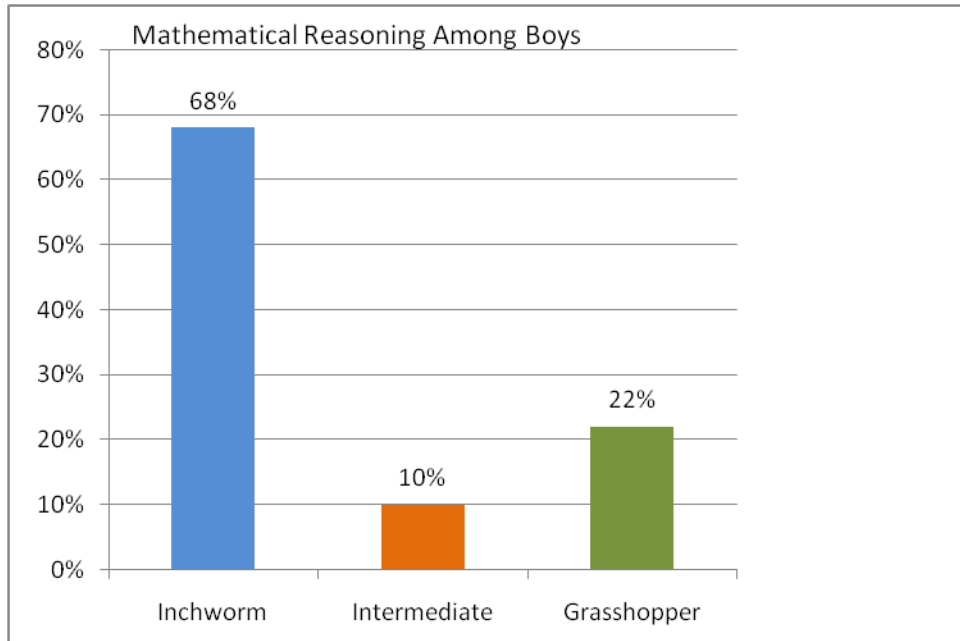**Figure 3.0 Cognitive Styles and Mathematical Reasoning among Boys**

Figure 3.0 indicates that, in mathematical reasoning, 68% of the boys were from Inchworm cognitive style, 10% from Intermediate thinking style and 22% were from the grasshopper thinking style.

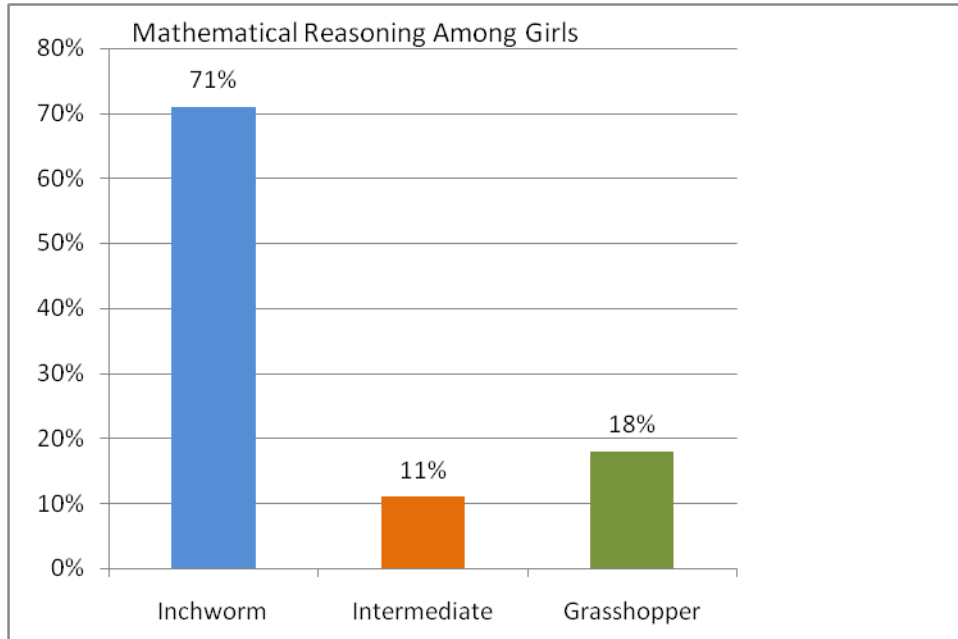**Figure 3.1 Cognitive Styles among Girls in Mathematical Reasoning**

Table 3.1 shows that, in mathematical reasoning among the girls, 71% were from the Inchworm cognitive style, 11% from Intermediate cognitive style while 18% exhibited grasshopper tendencies.

It is evident that, Inchworm is the dominant cognitive style among both boys and girls. More girls exhibited inchworm cognitive style while more boys demonstrated grasshopper cognitive style.

Table 2.4 Result of T-Test Differences in Cognitive Styles Based on Gender

Cognitive Styles	Sex	Std. Error Difference	Degree of freedom	t-Value	Sig.
Mathematical Concepts	Boy	0.128	156	-0.395	0.945
	Girl	0.128			
Problem Solving	Boy	0.158	156	0.559	0.504
	Girl	0.158			
Reasoning	Boy	0.128	156	0.494	0.323
	Girl	0.128			

The table 2.4 above reveals that there does not exist significance difference between boys and girls across the mathematical standards. The p>0.05 in all.

4.4 Objective Three: To study the relationship between Students' Cognitive style mathematical achievement

In the table 2.3 below, the mean of the upper half (students whole scored above 50) and the lower half (those who scored 50 and below) were calculated.

Table 2.5 The relationship between cognitive style and mathematical achievement

	Base Total	Mean score for Maths in term1 and term2	
		Less or equal 50%	More than 50%
	158	114	44
Inchworm	75%	79%	64%
Intermediate	12%	12%	13%
Grasshopper	13%	9%	23%

Figure 3.2 Cognitive style and Lower achieving students

Cognitive Style and Meanscore equal to or below 50%

Inchworm 79%
Intermediate 12%
Grasshopper 9%
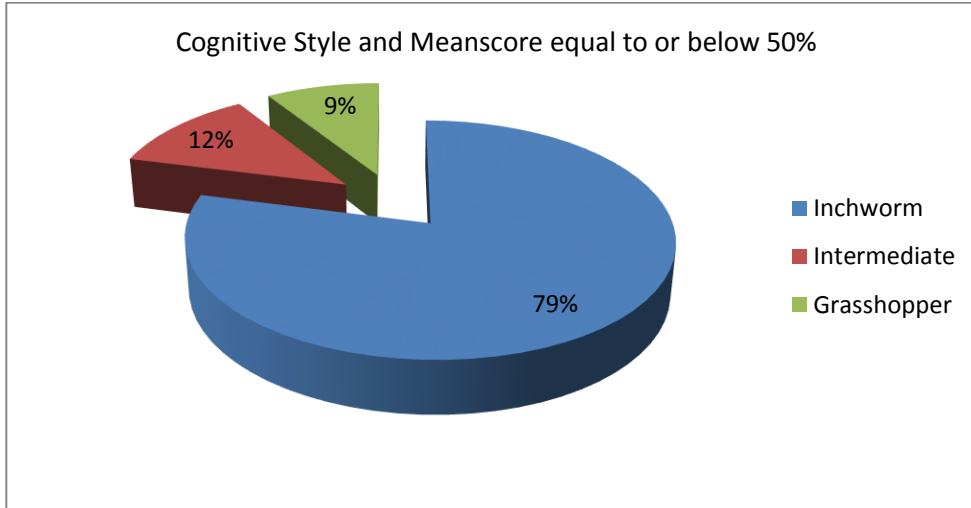
Figure 3.2 above shows that, among the Lower mean score students, 79% of the students were from the Inchworm cognitive style, 12 % showed intermediate tendencies and only 9% were from the grasshopper thinking style.

Figure 3.3 Cognitive style and High achieving students

Cognitive Style and Mean Score Equal to or Above 50%

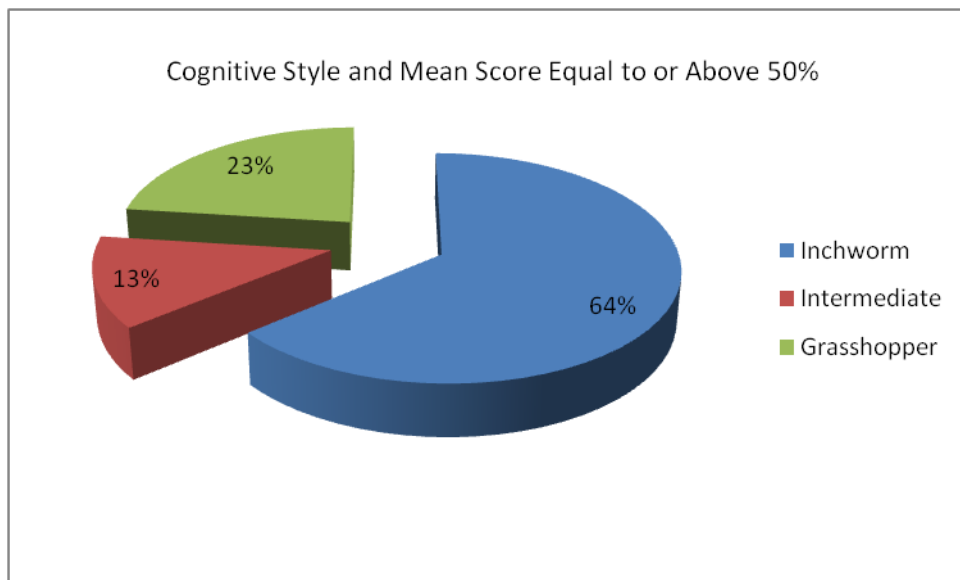Inchworm 64%
Intermediate 13%
Grasshopper 23%

Figure 3.3 shows that among the high achieving students, 64% were from the Inchworm

cognitive style, 13 % of the students showed intermediate tendencies while 23% showed Grasshopper cognitive style.

Comparison between the high achieving and low achieving students shows that there is direct relationship between students' cognitive style and achievement in mathematics. The high achieving students tend to be more grasshoppers (23%) compared to low achieving students (9%). The high achieving students also have less inchworm thinkers (64%) compared to low achieving students (79%).

4. 5 Summary of the Results

	Base Total	Gender of the Student		Level of the School		Mean score for Maths in term1 and term2	
		Boy	Girl	High Rank	Low Rank	Less or equal 50%	More than 50%
	158	79	79	82	76	114	44
Inchworm	75%	72%	78%	74%	76%	79%	64%
Intermediate	12%	13%	12%	12%	12%	12%	13%
Grasshopper	13%	15%	11%	14%	12%	9%	23%

CHAPTER FIVE: DISCUSSION, SUMMARY AND CONCLUSION

5.1 Introduction

In this chapter, the research discusses the findings of chapter four, summarizes the findings and makes conclusions based on the findings

5.2 Discussion

5.2.1 Objective One: To Identify the Students' Cognitive Style

Generally, the students (both male and female) tend to lean towards the Inchworm cognitive style meaning they prefer working in serially ordered steps documenting every step and the working is usually forward (Chinn 2012). There are students who exhibited Intermediate cognitive style meaning they are likely to use more than one cognitive style in a question or set of questions. This concurs with Chinn's study that cognitive style is a continuum ranging from extreme inchworm to extreme Inchworm. The implication of this is that the maths curriculum should be flexible enough to accommodate the range of thinking styles in mathematics. Teachers must also show flexibility in teaching because students possess different cognitive styles.

By the school rank, the students from high rank schools had more grasshopper thinkers compared to low rank schools. Indeed there was a significant difference between the high rank and low rank schools on problem solving and mathematical reasoning when subjected to the t-test on SPSS. This concurs with the previous study by Chinn (2012) who states that grasshoppers are better in problem solving. This was not the case on mathematical concepts where the difference was not significant.

5.2.2 Objective two: To determine the differences in Students' Cognitive style across gender

Regarding gender, girls tend to lean more towards Inchworm cognitive styles compared to boys even though the inchworm style is dominant style for both gender. However, the difference in gender did not appear to be significant when t-test analysis was applied. This is supported by a study done by Voyer (1995) who in his research could not find significant differences between males and females when participants were under 18 years old. The implication of this finding is that the mathematics curriculum should provide equal opportunities to both girls and boys. Further research is needed to explore this matter further.

5.2.3 Objective three: To study the relationship between Students' Cognitive style mathematical achievement

The trend indicate that the high achievers leaned more towards grasshopper cognitive style compared to the students in the lower mean score group. Nevertheless, inchworm cognitive style was still the dominant style for both high and low achievers. This study supports Grigorenko and Sternberg (1997) study who suggest that thinking styles significantly add to abilities as a tool for predicting academic achievement. Additional results from studies of secondary students' thinking styles also indicated a relationship between thinking style and student learning (Cano-Garcia & Hughes, 2000; Sternberg & Zhang, 2001). However, this study disagrees with a study by Azizi Yahya, Yusof Boon & Wan Zuraidah Wan Hamid (2002), tried to find the relationship between students'

cognitive styles and their academic achievement. Result of study showed that there was no correlation between cognitive styles and students' academic achievement.

The implication by this research is that the teachers must expose the students to both Grasshopper and Inchworm approaches to problems. This is referred to as meta-cognitive teaching because students get the opportunity to know about their own thinking and this will practically their success in mathematics.

5.3 Conclusion

There may be a challenge in the manner in which learners perceive the incoming information. This is because it cannot be categorically stated where the students lie (whether Inchworm or Grasshopper cognitive styles). Thus it cannot be stated that students have characteristics that influence how they respond and function in situations of learning.

The learners with difficulties in representing information and organizing the mathematical logic will find mathematics difficult. There is need to explore this issue further with more groups so as to be more comprehensive in the assumptions made.

5.5 Recommendations

a) The design of the mathematical curriculum should be made flexible to accommodate the diverse cognitive styles. This is a challenge to the curriculum developers

b) Teachers must spend time to know their students' cognitive and employ diverse mathematical teaching styles (pedagogy) that takes care of students preferences in the way they like to approach, organize and present information.

c) The mathematics assessment should include a mental test because students who do not prefer documentation (inchworm) will have a chance to demonstrate their mathematical understanding through mental math. The marking of exams should be flexible too and not just on stepwise procedural marking.

d) Extreme grasshoppers should be taught certain aspects of inchworm such as documenting one's thinking, and extreme grasshoppers should be taught some aspects of Inchworm such as estimating an answer to a problem before actual calculation.

e) There is need for further research on the impact of cognitive style on academic achievement in different academic subjects using different groups.

f) There is also need for research to determine the influence of teachers cognitive style o students cognitive style.

6.0 REFERENCE

Abdollahpour, M. A., P. Kadivar, and M. H. Abdollahi.(2006). Relationships Between Cognitive Styles, Cognitive and Meta-cognitive Strategies with Academic Achievement. *Psychological Research 8 (3–4): 30–44*

Alamolhodaei, H. (1996). *A study in higher education calculus and students' learning styles.* Unpublished Ph.D. Thesis, University of Glasgow.

Azizi Yahya, Yusof Boon & Wan Zuraidah Wan Hamid (2002). Relationship between Students' Learning Style and their Academic Achievement.*International Conference on The challenge on Learning and Teaching in Brave New World.* Hatyai City College Thailand and School of Cognitive and Education, UUM,14-16 October 2002. (Unpublished)

Baharin Abu (2000). *Teaching effectiveness and staff professional development programmes in HEI in Malaysia.* Unpublished Doctoral Thesis, University of Birmingham,UK.

Biggs, J.B., & Collis, K.F. (1991). Multimodal learning and the quality of intelligent behaviour. In H. Rowe (Ed.) *Intelligence: Reconceptualisation and measurement.* Hillsdale, N.J.: Laurence Erlbaum.

Blomberg, O. (2011). "Concepts of cognition for cognitive engineering". *International Journal of Aviation Psychology*

Bush, G. (2006). Learning about learning: from theories to trends. *Teacher Librarian*, 34(2), 14-19.

Buzan, T. (1983). *Use both sides of your brain*. New York: E.P. Dutton.

Cano-Garcia, F., & Hughes, E. H. (2000). Learning and thinking styles: Ananalysis of their interrelationship and influence on academic achievement. Educational Psychology.

Chinn, C.J. (2012). *The trouble with Maths: A practical guide to help learners with numeracy difficulties'*, 2nd edition. London: Routledge.

Chinn, C.J. and Ashcroft, J.R (1993). *Mathematics for Dyslexics: A teaching Handbook*. Whirr publishers. London.

Gardner, R. W., Holzman, P. S., Klein, G. S., Linton, H. B., & Spence,D. P. (1959). *Cognitive control. A study of individual consistencies in cognitive behavior: Part 4. Psychological issues.* New York: InternationalUniversities Press.

Grigorenko, E. L., & Sternberg, R. J. (1997). Styles of thinking, abilities, and academic performance. Exceptional Children.

Hanfmann, E. (1941). A study of personal patterns in an intellectual performance. *Character and Personality, 9,* 315–325.

Hayes, J., Allinson, C. W. & Armstrong, S. J. (2004). Intuition, women managers and gendered stereotypes, *Personnel Review. 33*, 403-417 Holzman, P. S., & Klein, G. S. (1954). Cognitive system-principles of leveling and sharpening: Individual differences in assimilation effects in visual time-error. *Journal of Psychology, 37,* 105–122.

Huberman, A. M. & Matthew B. M. (1994): Data Management and Analysis Methods. In *Handbook of Qualitative Research*. Norman K. Denzin and Yvonna S. Lincoln, eds. (Thousand Oaks, CA: Sage.

Kirton, M. J. (1989). Adaptors and innovators at work. In Kirton, M. J. (Ed.), *Adaptors and innovators: Styles of creativity and problem solving.* London: Routledge, 56-78

Klein, G. S. (1951). A personal world through perception. In R. R. Blake & G. V. Ramsey (Eds.), *Perception: An approach to personality* (pp.328–355). New York: The Ronald Press Company.

Klein, G. S., & Schlesinger, H. J. (1951). Perceptual attitudes toward instability: I. Prediction of apparent movement experiences from Rorschach responses. *Journal of Personality, 19,* 289–302.

Kim, T. S. (1996). The Relationship between cognitive style, ethnic group, and gender with Mathematic Achievement Among Primary School Students. *Unpublished Master of Education Theses. Universiti Sains Malaysia. Penang*

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall

Letteri, C. A. (1980). "Cognitive Profile: Basic Determinant of Academic Achievement."*Journal of Education Research 73: 195–199.*

Marton, F and Saljo, R.(1976). On qualitative differences in learning-1: outcome and process, *British Journal of Educational Psychology, 46, 4-11*

Messick, S. (1976). Personality consistencies in cognition and creativity. In S. Messick (Ed.), *Individuality in learning* (pp. 4–23). San Francisco:Jossey-Bass.

NCTM (1989): Principals and Standards for School Mathematics.Curriculum and Evaluation. INC.**http://www.fayar.net/east/teacher.web/math/standards/previous/CurrEvStds/index.htm**

Neisser, U. (1967) Cognitive psychology. Englewood Cliffs, NJ: Prentice-Hall

Norlia Abd. Aziz, T. Subahan M. Meerah, Lilia Halim, Kamisah Osman (2006). Relationship Between Motivation, Learning Style with Additional Mathematics Achievement among Form Students.Tingkatan 4. *JourrnalPendidikan* 31(2006). 123-141.Malaysia NationalUniversity.

Ofsted (2006) *Evaluation: Maths provision for 14-19-year olds*, London: HM Stationery Office.

Papanikolaou, K. A., Mabbott, A., Bull, S., & Grigoriadou, M. (2006). Designing learner-controlled educational interactions based on learning/cognitive style and learning behavior. Interacting with Computers, 18, 356-394.

Pask,G.(1976), *Style and strategies of learning*, British Journal of Educational Psychology, 46,128-48.

Piaget, J. (1973). *Main Trends in Psychology*. London: George Allen & Unwin

Ramlah Jantan dan Md. Nasir Masran.(2007). Relationship between Students' CognitiveStyle and Teachers'Teaching Style With Their Mathematic Achievement.Grant Research Report for Sultan Idris EducationUniversity.Tg. Malim : UPSI.

Rayner, S., and Riding, R., (1997). Towards a Categorisation of Cognitive Styles andLearning Styles. *Educational Psychology 17: 5–27.*

Riding, R. & Cheema, I. (1991).Cognitive styles-an overview and integration. *Educational psychology.*

Riding, R., J., & Rayner, S. (1998). Cognitive styles and learning strategies: Understanding style differences in learning and behavior. London: D. Fulton.

Ross, D.S. (2003), Mathematics, mind, ontology and the origins of number "Retrieved in 2004)

Russel, T. L. (1999). The no difference phenomenon. Raleigh, NC: North Carolina State University.

Schacter, Daniel L (2009). *PSYCHOLOGY*. Catherine Woods.

Schmeck, R. R. (1988). Learning strategies and learning styles, New York, NY: London: Plenum Press.

Sharma MC (1986) Dyscalculia and other learning problems in arithmetic: a historical prospective. Focus on Learning Problems in Mathematics 8(3,4): 7–45.

Sharma MC (1989) Mathematics learning personality. Mathematics Notebook 7(1,2).

Sternberg, R.J and Grigorenko, E.L (1995), Styles of thinking in school, *European Journal for High Ability.*

Skemp, R.R. (1986). *The Psychology of Learning Mathematics*, London: Penguin

Sternberg, R. J., & Zhang, L-F. (Eds.) (2001). Perspectives on thinking, learning, and cognitive styles. The educational psychology series. (pp. 197-226). Mahwah, NJ: Lawrence Erlbaum.

Sternberg, R. J., & Zhang, L-F. (2005). Styles of thinking as a basis of differentiated instruction. Theory into Practice, 44(3), 245–253.

70

Wagenschein, M. (1983). Erinnerungen für morgen. Weinheim: Beltz.

Witkin, H. A. (1950). Individual differences in ease of perception of embedded figures. *Journal of Personality, 19,* 1–15.

Witkin, H. A., & Ash, S. E. (1948). Studies in space orientation: IV. Further experiments on perception of the upright with displaced visual field. *Journal of Experimental Psychology, 43,* 58–67.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., & Karp, S. A. (1962). *Psychological differentiation.* New York: Wiley.

Witkin, H. A., Oltman, P. K., Raskin, E., & Karp, S. A. (1971). *A manual for the embedded figures test.* Palo Alto, CA: Consulting Psychologists.

Witkin, H & Goodenough (1977). Field Dependent and Field Independent Cognitive Styles and *Their Educational Implications.Review of Educational Research*.

Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Bretnall, P. M., & Wapner, S. (1954). *Personality through perception: An experimental and clinical study.* New York: Harper & Brothers.

Wonder, J., & Donovan, P. (1981). *Whole-brain thinking*. New York: William Morrow

Zazkis, R., E. Dubinsky, and J. Dautermann.(1996). *"Coordinating Visual and Analytic Strategies:* A Study of Students' Understanding of the Group d4.*" Journal for Research in Mathematics Education 27: 435–457*

Zhang, L-F. (2001). Do thinking styles contribute to academic achievement beyondself-rated abilities? Journal of Psychology

Appedix I: Student Assessment Tool

Name_____**Admission Number**_____

Thank you for agreeing to take part in this important survey that helps us to understand how you prefer to approach, organise and present logic of what you know. This will go a long way in improving teaching and learning in the classroom. The completion of this assessment takes about 40 minutes or so of your time. Use the space below each item to accomplish the task as you feel comfortable. The information received will be treated with utmost confidence and the results will not be used for any purpose neither will your name appear anywhere for others except to the research (who does not know you in person). Be assured that all your responses will remain confidential.

_____

1.   230 + 98

_____

2.   48 + 99

_____

3.   230 – 97

_____

4.   2 x 4 x 3 x 5

5. $95 \div 5$

6.   8
        6

        3

        4

        7

        2
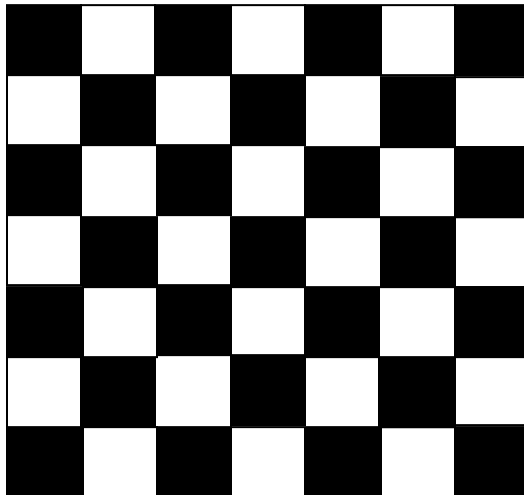
        +6

7.   600
        -498

8. Red pens cost sh 17. Blue pens cost sh 13. If I buy two red pens and two blue pens, how much do I pay?

9. If these are the first 14 letters, what is the 23rd letter in this sequence?

abcdeabcedabcd ....

_____

10. A film starts at 7.40 pm and ends 1 hour 50 minutes later. At what time does the film finish?

_____
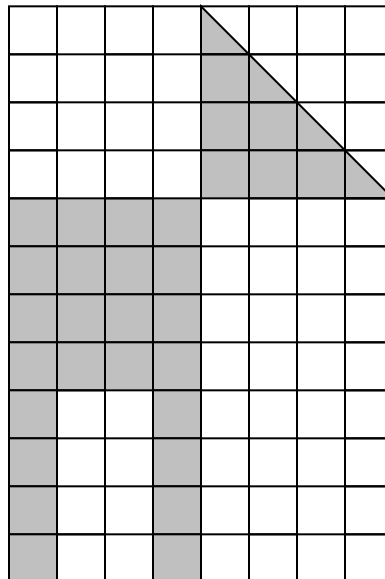
11. There are 49 squares in the figure. How many are black?

_____

12. There are 25 squares in the figure. How many have a cross?

---

13. What is the area of the 'horse'? How many little squares in the 'horse'?

Appendix II: Respondents' Assessment Tool

Name _____**Admission Number**_____ **Date**_____

Thank you for agreeing to take part in this important survey that helps us to understand how you prefer to approach, organise and present your information in order to improve the teaching and learning in the classroom. This questionnaire takes about 20 minutes of your time. Your responses will be kept under strict confidentiality. The statements labelled 'A', 'B', and 'C' (in some questions) represents the possible method you used to work each of the questions in the test. On the separate responses sheet put a check on the letter that corresponds to the method you used to work out your answer. If none of the statements represents your method, explain your method on the space provided as **"if other, explain your answer"** under each question and mark it 'D' on the separate responses sheet.

_____

1.

    A. I visualised as   230   vertically and solved sequentially, working
       from right

                      +98

to left, adding the units, $0 + 8$, adding the tens, $3 + 9$ and 'carrying' the 1 from the   12, adding   1 and 2 giving a final answer of 328.

    B. I adjusted 98, for example by adding 70 then adding 28 or adding 90 and then 8, but did not change 98 to another number
    C. I adjusted 98 to 100 and added to the 230 to make 330. The 330 is then adjusted by subtracting 2 ($98 = 100 - 2$) to give 328.

    D. If other, explain on the space below:

2.

    A. I visualised the problem vertically, then added sequentially from right to left by adding   ones 8+9 and 'carrying' 1 from 17, adding 1+4+9 giving the final answer as 147.

    B. I adjusted 99, for example by adding 90 then adding 9, but did not change 99 to another number.

    C. I adjusted 99 to 100 and then added to 48 to make 148. The 148 is the adjusted by subtracting 1 (99 =100 – 1) to give 147.

    D. If other, explain on the space below:

3.

A. I visualised the problem vertically then I subtracted sequentially from right to left by first renaming the 30   2 10

            2 ~~3~~ 0, then I subtracted the units 10-7=3. On the tens column since 2-9 cannot work, I renamed the tens using the hundreds column   1 12

                        ~~2~~ 2 0, then subtracted 12-9 to get the final answer as 133.

B. I adjusted 97 to 100 by adding 3, and then subtracted 230-100 = 130, I added 3 back to get 133.

D.If other method, explain your answer on the space below:

77

4.

A. I worked the answer sequentially as it is; 2 x 4 = 8, 8 x 3 = 24, 24 x 5 =120

B. I adjusted the order of multiplication to work it out as 4 x 3 = 12, and then did 10 x 12 = 120

D.If other, explain on the space below:

---

5. 95 ÷ 5   19

A. I visualised the problem vertically as   5) 95   dividing 9 ÷ 5= 1 reminder 4, 45 ÷ 5 = 9 giving the answer 19.

B. I worked by looking at 95 as close to 100. Then I divided 100 by 5 to get 20. Then I adjusted 20 to 19.

D.If other, explain on the space below:

6.

A. I added all the numbers sequentially from top to bottom and got the answer 36

B. I worked by first pairing numbers that make a 10, 8+2, 6+4, 7+3 giving 30. 30+6 =36

C.I first worked an estimate answer before I worked my answer

D.If other, explain on the space below:

_____

7.   600

     -498

A. I worked by renaming or regrouping by "borrowing" and paying back

               9
             5 10 10
             -4 9 8
              1 0 2

B. I used alternative regrouping/renaming procedure

         6 0 0
          5   9 10
         -4 9 8
           1 0 2

C.I worked by rounding 498 to 500by adding 2. Then I subtracted 500 from 600 to get 100. I then added the 2 back to get 102. I did most of my working mentally.

D.If any other method, explain on the space below:

_____

8.

A. I interpreted the question and worked it in three steps, 2 x 7 = 14, 2 x 13 = 26, 34 + 26 = 60 to get the final answer as sh 60.

B. I worked out by adding 17 and 13 to make 30. I multiplied 30 by 2 to get sh 60.

D.If any other method, explain in the space below:

_____

9.

A. To find the 23rd letter, I counted along the dots from 15 to 23, then recited the letters to match the numbers until 23rd letter 'c' is reached.

B. To get the 23rd letter, I looked at the pattern, 'abcde' and found that it repeats four times for 20 letters and therefore the 23rd letter is 'c'

D.If other method, explain on the space below:

_____

10.

A. I worked by adding the hour and then the minutes; 7 + 1 = 8pm, 40 + 50 = 90 minutes = 1 h0ur 30 minutes. Then did 8pm + 1hr 30 minutess to get 9.30pm

B. I worked by adding the minutes then the hour; 40 +50 = 90 minutes = 1 hour 30 minutes. Then 7 +1 = 8 + 1hr 30 min = 9.30 pm

C.I worked by first rounding 1hr 50 minutes to 2 hours, then added the 2hours to 7.40 to get 9.40, finally I subtracted the 10 minutes I had added to get 9.30 pm

D.If other method, explain on the space below:

_____

11.

A. I counted all the black squares

B. I counted the black squares in rows then added them 4+3+4+3+4+3+4

C. I first did total number of squares (7 x 7 = 49).Then I saw that there are more black squares because the corners are black. So there are 25 black and 24 white.

D.If other, explain on the space below:

_____

12.

A. I counted all the crosses

B. I counted the 3 sides each with 5 crosses to get 15; I then added the extra 2 to make 17

C. I saw a pattern of 3 x 3 = 9 blank squares in the middle, I added the extra one from the side to make 10; which I subtracted from 25 (5 x 5) to get 15.

D.If other, explain on the space below.

_____

13.

A. I saw the 'head' of the 'horse' as a triangle and so, ½ x 4 x 4 = 8, then the 'body' 4 x 4 = 16, the 2 x 4 for the area of the 'legs'. Adding the areas I get; 8 + 16 + 8 = 32.

B. I counted all the squares, using half squares in pairs to make one square

C.I saw that the triangle is half of a 4 x 4 square and the gap between the 'legs' is also half of

4 x 4 square. Moving the triangle into the gap creates two 4 x 4 squares (or one 8 x 4 rectangle) giving an area of 32.

D.If other, explain in the space below:

Appendix III: Student Self Analysis Responses Sheet

Name: _____**Admission Number:** _____**Date:**_____

Thank you for accepting to participate in this study. This is a follow up of the task you have just accomplished. You are asked to tick in the letter box 'A, B, or C' that corresponds to the statement that shows how you did your working. Check 'D' if only you used a method that is not found in the alternatives A, B, and C.

1. A   B   C   D

2. A   B   C   D

3. A   B   C   D

4. A   B   C   D

5.   A   B   C   D

6.   A   B   C   D

7.   A   B   C   D

8.   A   B   C   D

9.   A   B   C   D

10.   A   B   C   D

11.   A   B   C   D

12.   A   B   C   D

13.   A   B   C   D