Metacognition Strategies in Solving Mathematics at a Secondary School in Zambia

Chibumba Chidyaka
Post Graduate Student: Department of Mathematics and Science Education, School of education, University of Zambia. P. O. Box 32379, Lusaka. ZAMBIA

Bentry Nkhata, PhD
Lecturer: Department of Mathematics and Science Education, School of education, University of Zambia. P. O. Box 32379, Lusaka. ZAMBIA

Abstract
The main purpose of this study was to explore the metacognition strategies used by learners in solving mathematics problems at a Government Secondary School in Western Province of Zambia. This study was a qualitative case study. The semi-structured interviews were conducted to explore metacognitive strategies pupils used inside and outside the classroom in terms of their teaching experience, active participation, problem solving contexts, corrective feedback utterances and thinking enrichment opportunities during teaching and learning. The unstructured interviews were used to follow up interesting reactions, responses and stories during the mathematics lessons observed.A thematic Analysis technique was conducted where codes, categories and themes were used in analyzing the qualitative data. The codes came out from the actual words of the participants during interviews and observed lessons. Themes and categories came from the literature reviewed on metacognition. The study found that metacognitive strategies used by the learners were neglected. The study revealed that the main reason for neglecting them was that learners were not aware of them. The findings also indicated that learners were rarely engaged in constructive use of metacognitive strategies in their learning and study of mathematics. The highest used metacognitive strategies were clarifying learner's ideas, cooperative learning and problem solving. The fact that clarifying learners' ideas was highest indicated the much problems and complaints pupils faced. While the highest in cooperative learning and problem solving showed how much pupils interacted with one another in groups during mathematical problem solving but less of teacher's prompts to clarify value judgements on their strength and weaknesses. Furthermore, pupils used problem-solving activities more frequently indicated the extent cognitive processes were over- emphasized as opposed to them working simultaneously with the metacognitive processes. Pupils used least journal keeping, evaluating ways of thinking, planning strategy and identifying difficulty, which was a good indication that they could not use metacognitive strategies to record, set their own goals, assess their own thinking and be supported according to their individual needs. These results point that a teacher has to find ways of making mathematical concepts available to learners so that learning creates a metacognitive environment where mathematical authority empowers the learners' mathematical work to indulge in metacognitive strategies useful during lessons and their studies.
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1. Introduction

Rapid advances and developments in today's technology have brought about a need for an educational reconstruction. A subject like mathematics is dynamic and is never finished. The greatest virtue of mathematics is its flexibility. Contrary to this is some learners' inability to take mathematics as a flexible subject but rigid in rules and formulae. This factual knowledge of rules leave little room to develop pupils' understanding of thinking and learning (Reif, 2008). Many reflections have been made **on** learner difficulties in terms of taking control of their own learning and failure to link mathematics concepts and topics with one another that largely led to poor achievement levels (SACMEQ, 2011; Cockcroft report, 1982). The Examination Council of Zambia, ECZ (2012) revealed that only around 30% of Zambian children were meeting minimum levels of achievement in English, Mathematics and life skills at primary school levels. The National Assessment Survey of (1999:6) referred Zambia as a 'nation at risk' in levels of learning achievement. The problem of poor achievement is wider as can be attested from the 2015 results of a government secondary school studied. The picture portrays that only a small number of pupils (19.2 %) were able to get satisfactory grades (grades 1-6) which can offer someone a job according to the Zambian standards. Whilst, 14.5% ranged from grades 7 to 8. Such learners can be counted as having acquired a school certificate but will find it difficult to compete in the job market whilst the majority of pupils (64.2%) are failures. The pattern of failure in mathematics is a problem (ECZ, 2015).

Therefore, acknowledgement of mathematical strategies and skills is critical in our technologically sophisticated world in the teaching and learning of mathematics. Learning requires the active participation of the learners in their own learning by interacting with the environment. What enhances this active participation of learners is metacognition.

2. Difficulties learners find in mathematics

There have always been so many unanswered questions in terms of teachers' experiences regarding Mathematics despite the continued variations and growth in teachers' perceptions concerning teaching. In twenty-one years of teaching, the researcher reflected on the difficulties learners encountered in the learning of Mathematics. The difficulties mainly involved the following four aspects: (i) failure by many learners to link Mathematics concepts and topics with one another. (ii) The way some colleagues presented Mathematics using teacher-centred methods as their preferred teaching method as opposed to learner-centred methods. This often resulted in not wanting to answer or clarify pupils' concerns as active learner involvement was not encouraged. (iii) The learners' inability to study mathematics effectively. This aspect includes some learners' inability to take control of their own studies or not to be serious with mathematics. All that would be heard is that, 'mathematics is a difficult subject'. (iv) The majority of the learners would inquire about the application of Mathematics in everyday life. This aspect can also be related to the way in which Mathematics is presented leading to poor understanding of the importance of Mathematics. However, the researcher as a teacher of Mathematics always believed in the value of challenging learners to think. Instead of delivering Mathematics lectures, the researcher endeavoured to enhance active learner involvement and understanding by challenging their responses, asking them to motivate their answers, and establishing a safe and friendly classroom experience.

3. Leaner difficulties in mathematical problem solving

Difficulties in learning mathematics is very complex (Kramarski, Mevarech and Aramaic, 2002). Difficulties occur at all stages of the process solution, from the first stage (about understanding what the problem is), the planning process solutions and choose the right strategy, and the stage of deciding whether it makes sense or not. Another fact that is happening in the learning of mathematics are very rare authentic tasks. Kramarski, Mevarech and Aramaic (2002) revealed that they rare authentic tasks presented in mathematics class. This means that there are few teachers who know how to improve the ability of pupils to complete these tasks. Instead the default task are usually used as tasks that only illustrates a simplified situation involving some quantitative information with ready-made algorithms to be applied in solving specific problems. Another problem in mathematics learning is that learning is more passive (traditional learning) than active learning. That can cause silent knowledge structures (Schraw & Moshman, 1995) which is learning more of knowledge of cognition (knowledge capacity) and not the knowledge of metacognition (thinking capacity). Most of the difficulties in problem solving is generally as a result of failing to; organize the mathematical processes or problems, choose the most effective strategy, analyze, understand the point of the problem and to monitor and control processes carried out (Victor, 2004). It, therefore, becomes imperative to discuss in this study the emergence of problem solving in relation to metacognition strategies.

Therefore, since problem solving receives a lot of attention in mathematics education and literature. It is safe to say that problem solving has been the most written about, but possibly least understood aspect of metacognition in mathematics (Lester, 1994). In order to discuss the processing involved with problem solving, the notion of problem solving itself needs further clarification. Schoenfeld (1992: 11) presented the difference between solving problems and problem solving. The idea of solving problems is that pupils are completing "routine exercises organized to provide practice on a particular mathematical technique that, typically, has just been demonstrated to the pupil". In contrast, problem solving requires pupils to think about and solve problems with no set algorithm. Schoenfeld refers to problem solving as "the heart of mathematics" (1992: 14). In this theme, problem solving is viewed as working problems that required more thought process that allow pupils to decide how to solve the problem based on their knowledge and experiences. Wilson, Fernandez and Hadaway's (1993) study also distinguished the difference between solving problems and problem solving, noting that when speaking about mathematical problem solving, many different notions come to mind. According to Wilson et al., (1993: 60), problem solving should involve "exploration, pattern finding, and mathematical thinking" with consideration about teaching "How to think" and not ''what to do''. It also requires higher level questioning and thinking that help to establish the manipulation of information and ideas that, in turn, provides an opportunity to develop new ideas and understandings (Newton, 2002). The Zambian curriculum developers together with other stakeholders saw it appropriate that the level of questioning reflects the level of thinking expected within the classroom and in problem solving in the secondary school syllabus (MESVTEE, 2013). Hence, metacognition should be emphasized (Beyer, 2000) to maximize pupils' understanding in solving mathematics.

4. The definition of metacognition

Schoenfeld (1992: 9) describes "metacognition" as a term that was coined in the 1970s and only occasionally appearing in the literature of the early 1980s, but appearing with growing frequency through the decade, becoming (with problem solving) probably the most overused and least understood word of the 1980s. In this regard, research activity in metacognition were begun by John Flavell who is regarded as the "father of the field" (Papaleontiou-Louca, 2003: 9) and he also acknowledged that, 'in the field of cognitive developmental research, metacognition has become a main topic since 1973'.

Metacognition is a thinking system. Papaleontiou-Louca, (2003) defines metacognition as, ''all processes about cognition, such as sensing something about one's own thinking, thinking about one's thinking and responding to one's own thinking by monitoring and regulating it''(p. 12). It is the act of learning to learn, focusing, systematically planning what is going to be done, evaluating every phase of the learning process, and reflecting on the necessary arrangements accordingly. Furthermore, it is to be aware of learners' own cognitive processes, and controlling and directing these processes (Larkin, 2010).

Since the literature on the definitions of metacognition all have a common agreement on the word 'cognition', it becomes important to give a brief discussion of the concept of cognition in order to enhance the understanding of the concept of metacognition.

Larkins, (2010) defined Cognition as the mental action or process of acquiring knowledge and understanding through thought, experience and the use of senses. These cognition processes use existing knowledge and generate new knowledge. The cognition processes of generating new knowledge is driven by metacognition in relationship to further learning and as an application of a set of heuristics as an effective device for helping people organize their methods of attack on problems in general" (Hennessey, 1999). Larkin (2010: 3) refers precisely to the knowledge aspect of cognition when she states or adds the word "meta" indicating a change of position, or a second order or higher level, and "cognition" referring to a person's faculty of knowing or thinking. In this case, it seems that any attempt to discuss the nature of metacognition is inevitably linked to the problem of distinguishing between what is "meta" and what is "cognitive" (Georghiades, 2004). Following the discussion, metacognition can simply mean, "thinking about thinking", second level cognition or a higher thinking level.

The greatest vigor and interest in metacognition stems from the widespread belief that pupils must be lifelong learners, equipped with the skills necessary both to solve problems in school and to extrapolate these skills into life through understanding their own thinking, learning, and strategic approaches to problem solving. Thus, today, as stated by Aydin (2011), One of the main goals of education and as enshrined in the most of Zambia's education documents (MESVTEE, 2009; 2013) is to equip pupils,' the thinking skills and strategies which they will use throughout their lives, rather than storing information (p. 274). A good education should be able to show the pupils how to learn, how to remember, how to motivate themselves and how to control their own learning, so that they can teach themselves how to learn in order to be high thinkers or achievers '.

5. Learner metacognition and problem solving

Researchers have argued that emphasis on cognition (knowing) without a corresponding emphasis on metacognition (thinking) renders a problem-solving endeavor incomplete (Artzt & Armour-Thomas, 1998; Schoenfeld, 1992).). A rich store of knowledge is believed to be necessary but not sufficient requirement for successful mathematical problem solving (Garofalo & Lester, 1985; Schoenfeld, 1987; Geiger & Galbraith, 1998). However, pupils may be equipped with knowledge, strategies or skills to interpret the statement of a problem, inefficient control mechanisms can be a major obstacle during solution attempts (Carlson & Bloom, 2005). Carlson said that, irrespective of the richness of learners' knowledge bases, their inefficient control decisions often mean that known mathematical knowledge is not accessed, and general problem-solving strategies are, in that case, not employed.

It is has been concluded that pupils with high metacognitive skills perform better in problem solving (Desoete, Roeyers & Buysse, 2001; Schoenfeld, 1985). It has also been observed that during problem solving process, pupils;

- are more controlled,
- try to break the complex problems into simple parts and
- ask questions themselves for clarifying their thoughts.

Schoenfeld (1985) states that when one is encountered with failures in problem solving techniques, control skills (metacognition) will be helpful for applying successful strategies. Metacognition plays an important role during each level of mathematical problem solving. Goos, Galbraith and Reenshaw (2000) stated that a failure in metacognitive strategies ensures a corresponding failure in mathematical thinking and problem solving skills. Carr, Alexander & Foldes-Bennet (1994) said that metacognitive knowledge has the capacity to play a critical role in pupil achievement. Metacognition strategy is helpful to learners as they require increased metacognitive ability and require tasks appropriately developed and adapted to the capacity of problem solving.

It is extensively vital to acknowledge that mathematical skills and strategies are critically important in our technologically sophisticated world. In Zambia, associations such as the Zambia Association for Mathematics Education (ZAME) and Continuing Professional Development meetings (CPDs) are supportive of teachers' initiatives to develop such strategies while the mathematics club and JETS in schools nourishes pupils' understanding of mathematics. However, pupils' inability to perform well and satisfactorily to meet the national results required standards still posit challenges in the teaching and learning of mathematics for quality education of the 21st century. Amidst on-going efforts in strategies, UNESCO, (2014) urges that the surge for quality education and its continuation should be essential in order to foster learner-centered teaching and attain vision 2030 for innovative and lifelong education and training which is accessible, inclusive and relevant to individual, national and global needs and value systems (MESVTEE, 2013).

6. Teaching and Learning metacognition

Teaching metacognition pertains to observable and measurable indicators that capture teachers' implementation of a training of metacognition in more a socialization the classroom. Learning mathematics is a not simply an instructional process but rather a process where pupils develop ideas and behaviour patterns associated with mathematics. To develop these ideas and behaviours pupils need to be in the act of learning to learn or think about their own thinking using metacognitive strategies.

A teacher, as the More Knowledgeable Other (MKO) should have a deep understanding of the different metacognitive skills and strategies to be able to show the pupils what the strategies are, how to implement them, and under what conditions to implement them (Wilson, Bai, 2010). How the teacher implements this is of great importance in shaping what a class thinks mathematics is and this in turn will shape the kinds of mathematical environments one creates and thus the kinds of mathematical understandings that one's pupils possess" (Schoenfeld, 1992). According to the outcome based Education (OBE) in Zambia, there is need for individual learners to be able to perceive mathematics, to use it in their daily life and working life, to solve problems in today's information society, to think and decide independently, to express their opinions for long life (MESVTEE, 2013). MOE, (2009) urges teachers to use proper strategies of learner-centred teaching (LCT) to suit their own culture. Therefore, amidst LCT the missing link appears to be a lack of concern for metacognitive strategies that are key to learners' thinking about thinking in mathematics.

7. Teachers' knowledge about metacognition strategies

The knowledge about teaching metacognition to learners demands that teachers are bequeathed with pedagogical understanding of metacognition. Pedagogical understanding refers to teachers' knowledge regarding effective instruction for helping pupils achieve a goal (Wilson, & Bai, 2010). As long as the teacher has a comprehensive understanding of the diverse metacognitive skills and strategies, he or she can then show the pupils what the strategies are, how to implement them, and under what conditions to implement them (Wilson, & Bai, 2010). The manner in which the teacher implements this, goes a long way in shaping what a class thinks Mathematics is and this will in turn shape the kinds of mathematical environments one creates—and thus the kinds of mathematical understandings that one's pupils will develop (Schoenfeld, 1992).

Nevertheless, there is a gap between metacognition research and practices (Baker, 2017). The extent to which learners are capable of metacognition and the degree to which teachers teach metacognition in the classrooms are not similar to each other. Research highlights some of the reasons why teachers fail to guide learners to become metacognitive. Many researchers have found that non-cognitive influences, such as beliefs, attitudes, affect and motivation, could be linked to a learners' problem solving performance (Schoenfeld, 2010; Zimmerman, 2008). Some of the problems include time constraints and the difficulty of working with other type of problems, such as open-ended problems, which promote metacognition, when learners are used to finding the correct answer in the shortest possible time. Most teachers struggle to implement metacognitive intervention programmes productively as it is generally a challenge for them to change their conventional ways of teaching, often reinforced by the curriculum and culture of the school (Larkin, 2010). Furthermore, the teacher's own level of experience can influence the activities that promote metacognition in the classroom (Doganay & Ozturk, 2011).

A case study was conducted comparing how experienced and inexperienced elementary school teachers implemented metacognitive strategies in their classrooms. Doganay and Ozturk (2011), found that experienced teachers employed more metacognitive strategies and activities related to metacognition than did their less experienced colleagues.

Several studies were conducted to highlight various metacognition aspects. Abdellah (2004), conducted a study that examined the relationship between metacognitive awareness and academic achievement, and its relation to teaching performance of pre-service female teachers in Ajman University in United Arab Emirates (UAE). The study sample consisted of seventy five pre-service of Professional Diploma Female Students in Ajman University in UAE. A survey used in this study was the Metacognitive Awareness Inventory (MAI) and Teaching Performance Checklist. Findings asserted the importance of metacognition in learning. The study recommended that college professors have to adopt teaching technique and strategies in presenting information to students in a way that encourage use of metacognitive skills that has an effective impact on the academic achievement and teaching performance.

Esterhuyse (2015), conducted a study that focused on understanding the extent to which Intermediate Phase Mathematics teachers become aware of metacognitive strategies during an adapted lesson study process. To achieve this purpose, the study aimed at investigating the teachers' awareness of metacognitive strategies before and during an adapted lesson study process. Empirical qualitative research based on a design research approach took place within the interpretative paradigm. The results showed that most of the teachers were aware of the metacognitive strategies, but it can be that they lack knowing when, where and how to use these metacognitive strategies as they do not plan their lessons on a regular basis. Teachers also feel more comfortable when planning lesson collaboratively as they feel that they learn from one another.

Stephan and Kotze (2009), conducted also a study in South Africa that aimed at investigating the use of metacognitive strategies by Grade eleven Mathematics learners and their teachers. Two objectives were stated: To investigate which metacognitive strategies Grade eleven Mathematics learners and teachers of mathematics can employ to enhance metacognition among learners, and to investigate the extent to which Grade eleven Mathematics learners and teachers use metacognitive strategies. Questionnaires were used to obtain quantitative data about the use of metacognitive strategies by learners and teachers. The findings indicated that planning strategy and evaluating the way of thinking and acting were used most by both teachers and learners. Teachers and learners used Journal-keeping and thinking aloud least.

With such conflicts in the system, it is important that metacognition strategies be introduced deliberately into the school to foster learners' learning and academic achievement. Robert & Erdos (1993) assert that an ordinary person almost never approaches a problem systematically and exhaustively unless specifically educated to do so. Metacognition strategies are to be learned to allow a learner to apply self-monitoring in learning a task by breaking the different parts to the whole. In self-regulation, learning is from general to the specifics, which is an authentic process that enhances pupils' learning of Mathematics. However, school is full of learners who do not examine the quality of their work or stop to reflect as they go along. They do not make connections or see the relevance of the material in their lives. Satisfied with just scratching the surface, novice learners do not attempt to examine a problem in depth (Xiao 2007).

Papaleontiou-Louca (2003) acknowledges that the teaching of metacognitive strategies requires time and effort, but maintains that this investment is not in vain, as it results in more focused, flexible and creative problem solvers. Okoza and Aluede (2013) argue that a collaborative effort by relevant role-players should be made to equip teachers with the knowledge and strategies they need to mediate metacognitive strategies in the classroom. Designing more intervention programmes aimed at developing metacognition in learners and their teachers may not be the solution to the problem. Instead, teachers should be skilled to recognise situations that offer opportunities for the development and practice of metacognition in their day-to-day teaching (Larkin, 2010). Hence, there is need to recognise the infusion of metacognitive strategies in the teaching and learning of Mathematics in the Zambian curriculum. If truly there is need to transform classroom practice, metacognition should be introduced through in-service training for teachers and be introduced at high levels of training. This intervention should ideally take place in the space familiar to teachers-their own Mathematics classrooms. This would allow them to share their classroom practices, possibly opening up opportunities for reflection and evaluation (Pietterse, 2014; Van der Walt & Maree, 2007) even in other subject areas. Xiao (2007), said that the most effective way for teachers to teach their pupils to become metacognitive learners is to allow metacognitive instruction to permeate their curriculum. Adey and Shayer (1993), lend strong support to the view that metacognitive elements in thinking exist and can assist the transfer of learning, especially if the teaching explicitly targets metacognition as a key aim of the learning activity.

8. Metacognitive strategies

Flavell, (1981) defines metacognitive strategies as the," conscious monitoring of one's cognitive strategies to achieve specific goals" (p. 273). It is prominent for teachers of mathematics to have metacognitive strategies both for managing their own learning process better and for teaching these skills to their learners. It is important, however, to have a distinction between skills and strategies as presented in this study. Skills are learned abilities to do something automatic and are gained after repeated practice. While strategies are purposeful or effortful plans of action to achieve a goal wilfully and are facilitative in nature or in simpler terms a strategy is a skill under consideration.

Metacognitive instructional strategy is when the teacher knows that this is important and gives key prompts to learners to be more aware of their thinking by either questioning or discussing what they are thinking in a flexible thinking, planned study, and more effective problem solving skills. It is important to note that theorists agree that the most effective learners are those who can regulate their own learning (Azevedo, et al 2007).

While most learners are interested in effective performance, they often find it difficult to know the best strategies to achieve this goal. Learners need not to only make decisions in class but they need to learn how to organise their information as they learn. How this knowledge is organised will affect how much of the knowledge they can remember. It is difficulty to remember or use poorly organised knowledge (Reif, 2008). The knowledge of inexperienced students is often rather sporadic and poorly organised, consisting of concepts and ideas only loosely related to each other. Their sporadic knowledge can easily lead learners to misapplications and cannot readily be remembered. Then, after significant periods can go into oblivion. If a learner can change the way they organise their learning, it greatly facilitates the ease way with which knowledge can be remembered and appropriately retrieved (Reif, 2008).

Many teachers of mathematics in Zambia have tried to find better strategies to make learners understand but to no avail. Hence, Ministry of general Education (MOGE) on 13th June 2016 launched the catching up strategy to assist the large, slow and heterogeneous pupils to catch up. Nevertheless, without metacognitive strategies such as self-communication corners where a secluded place is identified for activating passive learning, it will be difficult to realise this dream. More so harder to create a metacognitive environment where mathematical authority empowers learners' mathematical work to indulge in metacognitive strategies useful during lessons and their studies. If pupils are not fully engaged in self-communication or verbal expressions, it will be difficulty as well to acquire metacognitive skills such as self-questioning, self-enforcement and set tangible goals for their individual success. Fisher, (2007) emphasised empowering pupils' habits of intelligent activities to build their cognition and metacognitive awareness in self-communication. By doing so brings out the learning process to a conscious level though teachers' prompts.

Therefore, it was important that learners develop an active, purposeful, and reflective strategy repertoire for their learning of Mathematics to personalise metacognitive strategies. According to Borkowski and Muthukrishna, (1992), "the aim of good strategy instruction is to provide opportunities for students to personalize strategies" (p. 492). Acquisition of metacognitive strategies leads learners to have skills in flexible thinking, planned study, and more effective problem solving skills. Hence, those with greater metacognitive abilities would tend to be more successful in their cognitive endeavors. The good news is that individuals can learn how to regulate better their cognitive activities (Livingston, 1997). There is reason to believe that building your metacognition can improve learning and intelligence. Boekaerts and Simons (1995) view metacognitive strategies as the decisions learners make, "prior to, during and after the process of learning "(p. 91).

Studies also show that metacognitive strategies enhance permanent learning and success (Cooper, 2008), improve questioning skills (Kramarski, 2009), develop social skills and success when used cooperatively (Flavell, 2000), enhance cognitive regulation (Mevarech & Amrany, 2008), help time management (Rosetta, 2000), and improve thinking and problem (Seegers and Veermeer, 1995) solving skills of learners. Similarly, (Desoete 2008) found that metacognitive strategies had positive effects on academic success and problem solving skills of learners. On the other hand, since learners have different metacognitive skills and knowledge, their learning pace and levels differ (Woolfolk, 1993). In line with this, the most effective way of self-regulation is the correct evaluation of what is known and what is not known when teaching and learning mathematics (Louca, 2003). There are various other metacognitive strategies aimed at developing learners' metacognition (Costa, 1984; Papaleontiou-Louca, 2003:), namely, planning questions, problem solving activities, choosing consciously, setting goals, evaluating the way of thinking and acting, identifying the difficulty, reflecting, elaborating and paraphrasing of ideas, clarifying ideas, cooperative learning and journal keeping.

i. Planning strategies

Planning strategy is a very important aspect of metacognition regulation. At the beginning of a learning activity, teachers should make learners aware of strategies, rules and steps involved in solving problems. Time restrictions, objectives and ground rules connected to the learning activity should be made clear and internalized by the learners. Consequently, learners will keep them in mind during the learning activity and assess their performance against them. Teachers can also encourage learners to share their progress, their cognitive procedures and their views of their conduct. It is difficult for learners to become self-directed when someone else plans learning (Blakey & Spence, 1990). Teachers should be able to identify problem areas in the learners' thinking about their thinking so that learners become more aware of their own metacognitive conduct (Costa, 1984). Planning strategy is a part of conditional knowledge of "**when**, why and how" pupils should use their metacognitive knowledge (Larkin, p. 2010).

ii. Generating questions

Blakey and Spence (1990) state that learners should ask themselves what they know and what they do not know at the beginning of a lesson activity. As the lesson activity progresses, their initial statements about their knowledge of the activities involved will be verified, clarified and expanded. Mevarech and Kramarksi (1997) came up with three kinds of metacognitive questions, namely comprehension questions where learners state the main ideas in the problems in their own words. The second is strategic questions which allow pupils to state the strategies that could be used to solve the problem and thirdly, connection questions – for example, stating what the similarities and differences are between the problem learners are currently solving and the problems they have solved in the past (p. 365-394). That is to say that learners should pose questions for themselves before and during the reading of learning activity and pause regularly to determine whether they understand the mathematical concept or if they can link it with prior knowledge and if other examples can be given or if they can relate the main concept to other concepts. Such metacognitive effective questions asked in a psychologically safe learning environment support pupil learning by probing for understanding, encouraging creativity, stimulating critical thinking, and enhancing confidence.

iii. Problem-solving activities

Studies on metacognition have proven that there is a strong correlation between problem solving and metacognition. Paris and Winograd (1990) state that metacognitive strategies are a "way of enhancing problem solving through cognitive tools" (p. 25). Problem solving involves higher order thinking processes such as understanding, analysing, synthesizing, generalization, and learning to think for themselves, which requires an integrated association. For example, when learners are only taught about heuristics and then have to work on problems at home, the teacher informs the learners that they are going to be asked the following three questions whenever they work on a problem: "What exactly are you doing?"; "Why are you doing it?"; and "How does it help you?". Gradually, it becomes a matter of practice for the learners to start asking the questions themselves, thereby improving their problem-solving skills. These skills enhances cognitive operations to work simultaneously with metacognitive processes as required in mathematics lessons.

iv. Choosing consciously

Guiding learners to explore the results of their choices before and during the decision process should be facilitated by the teachers. This will make learners able to recognize underlying relationships between their decisions, their actions and the results of their decisions. Metacognition involves many self-monitoring and regulation strategies including how you talk to yourself, pausing to collect your thoughts after some deep breaths to choose consciously. Metacognitive strategies of this nature allow you to objectively look back and reflect on a task. This can be done best when it is fresh in mind and not clouded by any emotional bias. Non-judgmental feedback to learners about the consequences of their actions and choices promotes self-awareness (Costa, 1984) and it enables the learners to learn from their mistakes, thereby actively building new knowledge from experiences encountered as they learn mathematics.

v. Setting and pursuing goals

A key component to metacognition is the planning stage before a task. One such metacognitive question, 'what do I want to achieve?' fits well with the research on the importance of goal setting. Artzt and Armour-Thomas (1998) define goals as "expectations about the intellectual, social and emotional outcomes for students as a consequence of their classroom experiences" (p. 9). Setting goals can help improve performance by focusing attention, enhancing effort and increasing persistence. However, the key caveat is that these benefits are only felt if goal setting is done correctly. Hence, it is upon the onus of the teachers of mathematics as the more knowledgeable to facilitate learners to achieve goals setting and goals set that are metacognitive in nature.

vi. Evaluating the way of thinking and acting

Metacognition can be enhanced if teachers guide learners to evaluate the learning activity according to at least two sets of criteria (Costa, 1984). Firstly, evaluative criteria could be jointly developed with the learners to support them in assessing their own thinking. For example, pupils could be asked to assess the learning activity by stating helpful and hindering aspects, their likes and dislike about mathematics. Accordingly, learners keep the criteria in mind when classifying their opinions about the learning activity and they motivate the reasons for those opinions (Costa, 1984, p. 60). Secondly, guided self-evaluation can be introduced by checklists focusing on thinking processes and self-evaluation will increasingly be applied more independently (Blakey & Spence, 1990).

vii. Identifying the difficulty

Costa (1984: 60) advises teachers of mathematics to discourage the use of phrases like "I can't do it"; "I do not know how to'' or "I am too slow to…" as they engage learners in class. Rather advises that learners attempt to identify the resources, skills and information required to attain the learning outcome. In addition, phrases like ''maybe'' or l will try next time'' should be avoided in class. These sentiments express no commitment to a discussion or decision. This entails that learners should be assisted to distinguish between their current knowledge and the knowledge they need. Through this, learners will have more conviction in seeking the right strategy for solving the problem in a metacognitive way.

viii. Reflecting, elaborating and paraphrasing of ideas

Teachers should use metacognitive monitoring to assist learners to restate, translate, compare and paraphrase other learners' ideas. Consequently, Costa (1984) supported that learners, ''will be better listeners to other learners' thinking and to their own thinking'' (p. 6). The teacher can respond, for example, "What you are explaining to us is…"; "I understand that you are suggesting the following…" Carpenter and Lehrer (1999) stated that the ability to articulate one's ideas requires profound understanding of significant aspects and concepts. They view the ability to reflect as a prerequisite for articulation and that articulation requires the identification of the essence and critical elements of an activity in mathematics. For example, learners discuss their thinking processes in pairs, in groups or during self-communication corners to help one another clarify their thinking by listening and asking questions.

ix. Clarifying ideas

Often, learners use ambiguous terminology when making value judgments. For example, "the question is not fair"; "the question is too difficult" or jokingly saying, l did not understand the question, repeat it just to avoid answering. Teachers should elucidate such value judgments, for example "Why is the question not fair?" what didn't you understand? Alternatively, "Why is the question too difficult?" (Costa, 1984: 61). If learners believe that mathematics is a collection of rules, then their learning might be influenced by their search for rules to memorise and to apply. Additionally, if teachers think of mathematics as a rigid formal system, then learners will remain unawares of alternative concepts or ways of perceiving mathematical concepts. Therefore, metacognition values such as communication judgements and clarifications of ideas are vital. Pimm, (1991) state that, "mathematics is not to be found just lying around to be picked up'' (p. 289). This entails that during metacognition teaching, a teacher, as the MKO, has to find ways of making mathematical concepts available to learners so that learning creates a metacognitive environment where mathematical authority empowers the learners' mathematical work to indulge in metacognitive strategies useful in the classroom.

x. Cooperative learning

Metacognition itself does not predict achievement, but researchers believe that it serves as a mediator to learning. Cooperative learning generates the opportunity for learners to work together in small groups to enhance metacognition. It entails more than group work for developing social skills and success when used cooperatively (Flavell, 2000). In cooperative learning, the teacher gives indirect guidance as the group works together to achieve specific learning outcomes (Killen, 2000). Teachers who may use cooperative learning when teaching view their pupils as active discoverers and creators of knowledge. Cooperative learning may promote awareness of learners' personal thinking and of others' thinking. From this perspective, the learning process should be viewed as a collaboration between teacher and pupil, in which the MKO develops pupils' competencies and critical thinking with active learning methods. When learners act as "tutors", Blakey & Spence, (1990. p. 2) the process of planning what they are going to learn in mathematics lead to independent learning and clarifying the mathematical concepts.

xi. Journal- keeping

Journal- keeping is a very important skill in learning in order to regulate and monitor our metacognition behaviours. Note writing is more than just a means of expressing what we think. It is a means of knowing what we think and a means of shaping, clarifying, and discovering our ideas. This can be done in form of keeping a personal diary throughout a learning experience that facilitates the creation and expression of thoughts and actions. Learners make notes of ambiguities, inconsistencies, mistakes, insights, and ways to correct their mistakes (Costa, 1984). This confirms their understanding of a concept. ". For the teacher, there is a gain in knowledge about pupil learning and the chance to refine both short and long term planning. Such kind of activities like journaling are one way of activating metacognitive skills.

9. An environment for metacognition strategies in solving mathematics problem

Chamot and O'Malley came up with a metacognition strategy- training model that helps teachers and learners to combine language, content, and learning strategies in a carefully planned lesson and developed the Cognitive Academic language Learning Approach (CALLA). In the CALLA model, pupils' prior knowledge and their habit of evaluation of their own learning seem to be the major principles. This model is recursive rather than linear in teaching and has five instruction phases as explained below (Chamot and O'Malley, 1994, p. 43-44)

In the first place, learners are expected to prepare for strategies instruction by identifying their prior knowledge about, as well as the use of specific strategies. This is exemplified by setting goals and objectives, identifying the purpose of a Mathematics task, over-viewing and linking with already known materials.

This is followed by presentation in which the teacher is expected to demonstrate the new learning strategy and explain how and when to use it. Normally this involves explaining the importance of the strategy and asking students when they use the strategy. This model collaborates with the theory which promote an arena (ZPD) for pupils 'interaction with the 'more knowledgeable other' so as to adapt in their learning.

What follows is practice, whereby learners are expected to practice using the strategy with regular class activities. This demands that the teacher encourage asking questions, cooperating with others, and seeking practical opportunities among the learners.

In the evaluation stage, learners are expected to self-evaluate their use of the learning strategy and how well the strategy is working for them. This is characterised by self-monitoring, self-evaluating, and evaluating their learning. The last stage involves expansion in which students extend the usefulness of the learning strategy by applying it to new situations or leaning for them such as arranging and planning their learning.

The CALLA model relates to a metacognitive environment where the teachers of Mathematics provide support to pupils so that they are able to achieve task demands. During CALLA, it is important to remember that the teacher is involved in facilitating some of the task demands because pupils cannot manage them on their own. As pupils' efficiency with problem solving and successful task completion increases, teachers fade their assistance so that learners evaluate their metacognitive effectiveness on activities themselves. However, it is important for teachers to understand that learning to teach with metacognition "will develop slowly overtime, much in the same way that other mathematical ideas are known to develop (Lester, 1994).

Furthermore, metacognitive strategies in solving math problems are essential in math education. It has always been a challenge for educators to teach pupils on how to solve problems. As should be noted that problem solving is not just a method in Mathematics, but a major part of learning Mathematics where the pupils deepen their understanding of mathematical concepts by examining and blending their knowledge. Learning is a thinking process. It requires the active participation of the learners in their own learning by interacting with their own environment. This implies that learners' awareness of their own thinking, using this awareness in controlling the things they do, using thinking processes such as memory, attention and imagination, and using learning to learn skills indicates that metacognition is interrelated with all thinking dimensions (Larkin, 2010). Therefore, it becomes more permanent with the increase in thinking processes involved. Thereby in such process, studying becomes defined as the effective use of certain techniques for learning purposes in Mathematics. The process of studying is actually a process of problem solving. In such a process, learners' planning, organising, and evaluating the things they are going to do will inform them about the way to follow, and this will affect their performance in a positive way (Curvens et al, 2010).

In the context of problem solving sustainability or permanence ability, according to CALLA, pupils should be asked the following questions before they begin a task;
"What do you already know about this problem?"
"What is the goal or reason for engaging in extended and careful thought about this problem?"
"How difficult do you think it will be to solve the problem?"
"How will you know when you have achieved the goal?"

As pupils work on a problem, they should be asked to assess their progress, and when the task is completed, which strategy to use as well as how well the problem was solved and what they learned from solving it. By so doing, pupils will develop self-assessment skills, that is, the ability to evaluate correctly their knowledge level of metacognition and later become good mathematical problem solvers.

10. Learning Theory used in the study

This study was inspired by Lev Vygotsky's (1978), social-cultural theory. The socio-cultural theory has emerged as one of the major influences on classroom research in the fields of teaching, learning and cognitive development (Cross, 2010). Sociol-cultural theorists believe that children learn mainly through social interactions with other people in their immediate social world. It treats learning as a social process where whatever children learn is influenced by the beliefs and customs of the specific social and cultural contexts in which they are positioned (Vygotsky, 1978).

The study used Vygotsky's three vital concepts to try to explain the interactions and relationships between teachers and learners in the classroom as their social cultural environment. These are mediation, which shall be used interchangeably with teaching, the Zone of Proximal Development (ZPD) and internalisation.

The concept of mediation (teaching) is not just to assist learners to solve a problem, but to identify the minimum level of support a learner requires to successfully complete a task with the most knowledgeable other who is the teacher (Lantolf and Poehner, 2013). The teachers' knowledge and role in assessing the learning of Mathematics through learners' social cultural paradigm is important. The teacher should know that what is important is not what the learners have already learnt, but what they are capable of learning (new information). When teachers have understood how learners learn they will modify the learning to suit different needs.

The ZPD is the arena in which social forms of teaching occur and it defines the maximised conditions of learning in the classroom (Ableeva & Lantolf, 2011). Additionally, Vygotsky (1978), identified the ZPD as the distance between what a learner can accomplish alone and what he or she can accomplish with the help of a more capable person. 'The distance is between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under the adult guidance or in collaboration with more capable peers." (Vygotsky, 1978, p. 86). The teacher who is the More Knowledgeable Other, (MKO), should model learning activities in such a way that they begin with what the learners can do independently (actual development) then link with what they can perform with assistance (potential development) (Siyepu, 2013). The potential developments of the teacher are needed most to guide the learners' learning using clues, clarification, motivation, suggestions, regulating, joint participation and controlling the learner's attention span (Lindblom & Ziemke, 2003). Vygotsky (1978, p. 78), states, "what is in the ZPD today will be the actual developmental level tomorrow''. That is to say that whatsoever a learner can do with assistance today, he or she will be able to do it alone tomorrow. During such an activity, learners will gain the knowledge, strategies and skills to solve problems independently that were previously beyond their reach and at this level we say they have internalised what they have learnt. Vygotsky (1978), believed that internalisation directs the child's development and that, "through others, we become ourselves".

It is through the correlation of the three concepts that teachers are supposed to continuously gauge the learner's readiness to take more control, modifying the teaching accordingly until the learner can function independently though it is at the pupil's discretion on how to respond. An effective teaching and learning should offer consistent opportunities to all learners at different levels of development to extend their knowledge, beliefs, abilities and strategies. Bowie, *et al* (2015), cited in a Grade eleven Teachers' Hand Book emphasises on an outcome-based education where learners are able to realise their potential through knowledge and skills for long life. Hence, the teacher has to adapt their teaching strategies and manage their classrooms to accommodate the full range of learning abilities and needs for learners to achieve their goals. The teacher's role, which is central in the analysis of this research, is to create a learning environment that offers abundant opportunities for active participation involving imparting appropriate information and teaching explicit knowledge, skills and strategies of metacognitive nature.

11. Methodology

The study was a qualitative case study in nature because the research question was open-ended in order to explore how teachers use metacognition strategies in their mathematics classrooms. Creswell (2009), stated that qualitative research is a means for studying a topic by exploring and understanding the meaning individuals or groups assign to a social or human problem. Whilst Patton (2015), added that it is a way of exploring further the meanings people have constructed with the ultimate concern to understand the phenomenon of interest from the participants' viewpoints, adding richness and depth to the data in any particular context. Not only are they a flexible method for collecting qualitative data, but they also enable the researcher to tap into the multiple aspects of the interview, such as verbal and non-verbal communication, listening and speaking (Patton, 2015). These offered the kind of information that was hidden in a written response.

This research targeted five teachers of mathematics for lesson observations and thirty pupils for metacognitive strategies checklist interviews who were purposefully selected. According to Creswell (2009), using this sampling technique, the researcher purposively targets a group of people believed to be relevant for the study. In this study's context, purposive sampling was appropriate because it focused on people who were knowledgeable, reliable, relevant and interested to the research study as compared to other sampling procedures where respondents chosen may be unable to give the required data (Lisa, 2008).

The purpose of lesson observations was to experience first-hand information of what transpired in class with the view to seeing what sort of learning activities are used in order to unveil the teaching practices from a perspective of promoting metacognitive strategies. The interviews were semi-structured and unstructured [post-lesson observations]. The semi-structured were used to explore thirty pupils' ideas on the use of metacognitive strategies in the learning and studying of mathematics using a metacognitive checklist [Appendix A: Tables 1 & 2]. The post-lesson interviews were unstructured questions in order to allow the researcher to explore further respondents' responses form the observed lessons. They were one-on-one interviews with one or two pupils from the observed lessons. Questions asked dealt with among others pupils' learning experience, active pupil participation, problem solving skills and thinking enrichment opportunities in terms of how they used metacognitive strategies during lessons.

Qualitative data from lesson observations and interviews were transcribed fully (changed into written form) since they constituted raw or undigested information that needed to be developed into some manageable classification. The interviews were transcribed immediately after each session to reduce on the workload and were constantly reviewed on a sound recorder to familiarise with the data. It was an eclectic process where sense was formulated out of the collected information through data generating instruments.

The process of analysing data was quite challenging. Data were analysed using a process called thematic analysis. Thematic analysis is one of the most common forms of analysis in qualitative research (Guest, Greg (2012). According to Braun and Clarke (2006), thematic analysis is "a method for identifying, analysing and reporting patterns within data" (p. 79). Thematic Analysis is an approach to dealing with data that involves the creation and application of 'codes' to data. This suggests that it is not only a matter of counting phrases or words in a text but goes beyond to identifying implicit and explicit ideas within the data through a cyclic reading of the data toward discovering patterns, developing categories and labelling themes (Creswell, 2009). Themes and categories were derived from those that the researcher identified from the literature reviewed while codes with appropriate verbatim quotes came from what the teachers and pupils said and very significant to the study's focus of inquiry as appeared in Romans.

After coding all the transcripts, the researcher with the help of a co-researcher analysed the data manually. All chunks of coded data were assembled on wide pieces of Manila paper. Then, codes were allocated under appropriate groupings, grouping together chunks with the same codes. During this phase, chunks were re-examined, compared and searched for patterns in the coded data in order to form categories. The codes were grouped into categories according to their similarities as related to the research objectives and questions. When all codes were categorised, the categories were grouped according to their related significance and presented as a theme. The themes were once again read several times to make sure every data captured was in relation to different themes that were generated according to the researcher's understanding of the topic from the literature reviewed. To prevent a disorderly analysis of the data, Zhang and Wildemuth (2009) suggest using Glaser and Strauss's constant comparative method. The constant comparative method involves breaking down the data into discrete units and coding them into categories. It helped to expose the differences between categories and themes as well as easy triangulation of data. The task of reducing data, identifying categories, later themes and awarding of well-argued, reflective conclusions was the qualitative researcher's greatest analytic challenge (Suter, 2012).

Hence, these structured themes led to an elegant understanding and discussion of results, which were supported with appropriate verbatim quotes from what the teachers and learners said. Thus, classifying and coding qualitative data produced a framework for organising and describing what has been collected during fieldwork (Patton, 2015). Patton (2015), further says this descriptive phase of analysis builds a foundation for the interpretative phase, when meanings are extracted from the data, comparisons are made, creative frameworks for interpretation are constructed, conclusions are drawn, significance is determined, and in some cases, theory is generated.

12. Results

The learners play a crucial role in the teaching process. The learners' current level of development determines how teachers will adapt their teaching strategies. Concerning metacognitive strategies used by learners in solving mathematics problems, two themes emerged; metacognitive skills and self- communication through lesson observations and interviews.

12. 1. Metacognitive skills

12. 1. 1. Metacognitive strategies used by learners

This section explored metacognition strategies used by learners in solving mathematics problems**.** During the semi-structured interviews, learners were asked to explain what metacognitive strategies they used most in their learning [see Table 1]. The blank boxes in Table 1 indicated those pupils who did use the metacognitive strategies whilst the X indicated pupils who were not aware of the metacognitive strategies. A metacognitive strategy checklist in Table 2 was used to display the frequencies according to Table 1.

The metacognitive strategies that implemented most by the learners were clarifying learners' ideas (22), Problem-solving activities (20) and cooperative learning (20). The least used among learners were journal keeping (01), Setting goals (02), evaluating ways of thinking (02), planning strategy (03) and identifying difficulty (03). This, therefore, shows that learners have specific metacognitive strategies, which they mostly focus on whilst others are either not emphasised or not known.

During the unstructured interviews, learners were asked to explain how they learnt metacognition during mathematical problem solving. It also explored strategies teachers employed to meet the diverse needs of learners in the classroom. The data collected from classroom observations and interviews was used to analyse how the pupils were taught metacognition during mathematical problem solving. Especially the statement by a fast learner, PG12B, related to the use of clarifying one's ideas. "… *I didn't get what the teacher explained and tried to figure it out myself.* He was *rushing to avoid my question* and when you *insist t*ells you to just concentrate or you'll fail. The questions you give are vague. But even him sometimes he gets confused on the board, he writes and rubs. I sometimes get nothing; I just brush off. So that I find out, I *ask from fellow pupils* in order to *pass the exam".*

12. 1. 2 Self-reflection

In a similar vein, in self-reflection, PG11A stated that ". I was free to put my thought to the problems in the group, I acted as a group leader and that gave me more work to show my ability when I was explaining to others. I first plan the things I am going to do in mind. Then, PG12C talked about his learning experiences, "I do not make the *mistake of studying* for all the lessons at the same time since I want to *be organised* in what I do. I tried to reflect on the examples we do so the I don't *make mistakes***.** I *go through the exercises and homewor*k before I study and I get pleased for doing so.

While PG12B expressed her thoughts in self-reflection and journal keeping, "I *ask the teacher for topics* in advance so that I study in advance. As she is talking, I make sure I *jot down some points*. Usually in math, there are no notes but for me, it helps me to go through alone when I go home and I *easily remember***.** …..Yes, it's my *own imitative* … I am good in math and I always *get above 60%.*

12.2. 1. Self-communication

Here is an extract from observations and leaners' post-lesson interview concerning self-question, self-rein-reinforcement and setting goals in their classrooms.

Researcher: How do you contribute to your learning?

Learner: Nothing. The teacher *brings everything*. Teachers do all the preparations, us we just follow. Sometimes they *jump topics* and those are the ones that *come during exams*.

Researcher: Did you recheck mathematics problems after solving them?

Learner: sometimes when time is there but mostly the teacher *does not finish marking* our exercise books. The next lesson will start this make me *feel bad about the subject* and I *don't know what the teacher thinks* and *don't consciously do* it but they, it's probably because they felt .. they felt that they were *covering the work.*

Researcher: You took time talking during group discussions, what was it all about?

Learner: The teacher didn't consider my suggestion in the first place but my method was *working so well*, shorter

and easier than what was given on the board. So I was trying to explain but …but time was not in favour. She didn't allow me to solve it on the board…and it was quiet embarrassing. It is important that they listen to us also but all they *think is that all is correct or right* so long the answer is found.
Researcher: What do you do when you fail to understand in class?
Learners: I ask other people [teachers, friends] to help me b'cos if you ask the teacher he'll just *embarrass* you in front of others and sometimes I just *keep quiet*. There is no *other platform* when you fail to understand.
Researcher: How did you ask questions in class?
Learners: During *group discussions*. We *talk, share ideas* and then *present to the class*.
Researcher: What do you want to achieve at the end of Grade 12?
Learner: My goal is to *study hard* and *pass the exams* so that I *get a job*.
A summary of how the participants' actual words were coded appeared on Table 3.

13. Discussions

In all dimensions of the metacognition skills, there was less emphasise of metacognitive strategies among pupils in all classes observed. Findings obtained from the semi-structured interviews corresponded with those obtained from the post-lesson interviews. The metacognitive strategies that learners implemented most were clarifying learners' ideas (22), Problem-solving activities (20) and cooperative learning (20). This, therefore, shows that learners have specific metacognitive strategies, which they mostly focus on whilst others are either not emphasised or not known. The fact that the learners used clarifying learners' ideas more often just like cooperative learning shows the varied extend on the emphasise of metacognitive strategies and self-communication in the classrooms. Often as learners work in small groups, they used ambiguous terminologies such as, "the question is too hard and I can't do it or it's this one who can solve or do it not me". Such value judgements should not be encouraged in a classroom situation. Instead, the teachers should elucidate positive statements as pupils work like, "why is the question not fair or go try and solve it we see where you will face problems, or ask what they didn't understand. The fact that the learners used problem-solving activities and cooperative learning more could explain why pupils were left to work on their own without much assistance or verbal prompts to think. More so, cooperative learning indicated how much pupils can interact with one another in groups with less of the teacher's prompts.

The metacognitive strategies that were implemented least by the pupils were encouraging journal keeping (2); setting goals (2); evaluating ways of thinking (2), planning strategy (3) and identifying difficulty (3). Keeping of a journal was least used by pupils implies that having a record of what is taught was not encouraged among pupils and it showed that pupils were not keeping a written record of mistakes they tend to make and perceptions they gain when learning. Pupils should be encouraged to make their thinking audible or visible by communicating what they are thinking, be it in written or verbal form. Furthermore, considering that learners used evaluating the way of thinking and acting and identifying difficulty least entails that learners cannot identify their strengths, weaknesses, mistakes and successes in mathematics, hence not able keep a written record of this self-knowledge. Only one pupil was seeing note taking something during lessons just like Stephan and Kotze, (2009) observed.

A learning of metacognition suggests that teachers have better adapt instructions to pupils' needs. For this purpose, as McDevitt and Ormrod (2016) emphasized, pupils need to describe their mind. In order for pupils to describe their thinking about the mathematics, teachers have to "identify inconsistencies and gaps in their [students'] understanding of concepts" (p. 265) and that is when a metacognitive discussion can be attained. With pupils who reflect on their thinking about the mathematical problem, a teacher can help them to recognize their own strengths and weaknesses regarding strategic use and appreciate the benefits of thinking about the mathematical problem on understanding, how to solve it and strategic choice.

Additionally, since self-communication was not used effectively, most of the learners were not able to check what, how and why they are doing things in mathematics. Learners in the four observed classes were disorganised and made unconstructive noisy except in G12A where they were few. Learners working in a group should ask themselves constructive questions like, "what should I /we do first" or if it's wrong, is there anything missing". Such pupils are those who are aware of the times they are thinking or acting in a strategic way or not. This finding correlated with that of (Karakaya, 2001) who said that a process like this would," create a learning environment that is based on cooperation and in the environment where pupils see the other pupils as a resource rather than rival" (p. 110). It would also create a metacognitive environment where mathematical authority empowers the learners' mathematical work to indulge in metacognitive strategies useful in the classroom.

Another justification of the findings would be that problem-solving activities were highly ranked while setting goals was among the least. The pupils who are able to set goals are able to be good problem solvers. The more effective studying habits they become, the more effective studying habits have, the higher their metacognition level becomes (Panaoura, & Philippou, 2007). During observations and interviews, only a few pupils were able to reach such standards. This showed that there was a conflict in the dual process between the habit of studying and metacognition, which should have been the pattern by most pupils observed. By encouraging pupils to question and communicate why they should or want to understand a mathematical problem, teachers can foster pupils' autonomy and goal-directed mathematics experiences and give a voice to pupils' personal goals and expectations in learning mathematics (Zimmerman, 2002). When pupils do self-questioning, self-reinforcement and set goals regarding their purposes, they have something to think about and value. This is when metacognitive thinking occurs in real time (Larkin, 2010) and life.

Talking about time and life, it is important to consider a sociol-cultural point of view that when learners are working either individually or in a group with their peers, the presence and active role of the teacher or More Knowledgeable Other (MKO) or final form are non-negotiable. If the final form is not actively involved in the learning process, "the development of the child turns out very limited and what results is a more or less completely underdeveloped state of the child's proper forms of activity and traits" (Vygotsky, 1994. p. 350).

Some of the learners explained of how their own beliefs and attitudes influenced the way teachers taught mathematical problem solving. Most of them expressed their dislike of the subject on the teachers' attitude especially when asked questions. Learners said that teachers' lack of seriousness and bad remarks cause their apathy to participate actively. However, Larkin (2010) explain that beliefs and opinions originate from our experiences. Thus, the experiences teachers held as school learners can influence their beliefs and practice of teaching, which in turn influence the experiences of their learners. Consequently, they will be tempted to only teach for exams and not for understanding. However, Learning should not be for passing exams only, but build competences for long life living (MOE, 2013).

14. Conclusion and Recommendations

In conclusion, the study found that metacognitive strategies used by the learners were neglected. The study revealed that the main reason for neglecting them was that learners were not aware of them not until the researcher started asking them. Learners were very interested to be asked such metacognitive types of questions in nature. The study discovered that the metacognitive strategies that were implemented most by the pupils were clarifying learners' ideas, problem solving activities and cooperative learning and those that were used least are journal keeping, talking aloud and evaluating ways of thinking. The fact that clarifying learners' ideas was highest indicated the much problems and complaints pupils faced. While the highest in cooperative learning and problem solving, subsequently, showed how much pupils interacted with one another in groups during mathematical problem solving but less of teacher's prompts to clarify value judgements on their strength and weaknesses. Furthermore, pupils used problem-solving activities more frequently indicated the extent cognitive processes were over- emphasized as opposed to them working simultaneously with the metacognitive processes. Pupils used least journal keeping, evaluating ways of thinking, planning strategy and identifying difficulty, which was a good indication that they could not use metacognitive strategies to record, set their own goals, assess their own thinking and be supported according to their individual needs.

Furthermore, the scattered variations on how learners used the metacognitive strategies showed how rarely they were emphasised by teachers in motivating learners to learn. For instance, the fact that clarifying learners' terms occurred more often and evaluating learners' thinking was used least showed that pupils experienced many challenges in their learning and more needed to be done to assist them understand their weaknesses and strengths. Evaluating the way of thinking and planning strategies were among the least. This could indicate that learners were disorganised and not aware of their strengths and weaknesses in Mathematics.

This disorganisation in learning posited that many learners did not like mathematics because they do not understand how best to learn it. Learners did not regularly inquire about effective study ways in mathematics because teaching was not providing alternative ways or strategies. If pupils were to be equipped with various metacognitive strategies, they would in return develop metacognitive skills in self-communication [self-questioning, self-reflecting, goal setting] for learning endeavours.

The general observation was that a teacher, as the MKO, has to find ways of making mathematical concepts available to learners so that teaching and learning creates a metacognitive environment where mathematical authority empowers the learners' mathematical work to indulge in metacognitive strategies useful in the classroom.

The use of metacognitive strategies could address these concerns by teachers through making value judgements on learners' ideas and feelings so that they could make informed decisions towards their attitude to mathematics. Learners' self-knowledge and self-reflection could also be improved by keeping a record of their daily encounters when learning in terms of strengths and weaknesses. Teachers have the opportunity to demonstrate to the learners the relevance of mathematics in everyday and future lives by assigning real-life problems (problem solving activities).

The results point to the importance of teaching and learning metacognitive strategies. In this way, pupils will study and learn mathematics effectively. Pupils will develop planning, organizing, self-monitoring, and self-evaluating skills for their own learning, and this will contribute to their being independent learners and good problem solvers for their future in mathematics.

The followings are suggested in the light of the findings of the study:

1. Teachers should provide learners with guidance on the use of metacognitive strategies so that they are

able to identify their strengths and weaknesses to actualise their efforts.
2. Teachers' association (ZAME) and Group Meetings CPDs) should emphasise metacognition teaching and writing.
3. Schools should try to build a positive attitude in the learners to catch up through self-communication corners in the classrooms, which can as well be useful in other subjects.
4. The curriculum should include activities based on metacognitive strategies especially on effective study skills in a more comprehensible way.

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REFERENCES
Abdellah R. (2015). *Metacognitive awareness and its relation to academic achievement and teaching performance of pre-service female teachers in Ajman University in UAE*. Procardia - Social and Behavioral Sciences 174 (2015) 560 – 567.
Ableeva, R. & Lantolf, J. (2011). Mediated dialogue and the micro genesis of second language listening comprehension. Assessment in Education: Principles, Policy & Practice, 18(2), 133-149. doi:10.1080/0969594X.2011.555330.
Adey, P. & Shayer, M. (1993). Really raising standards. London: Routledge.
Artzt, A. F., & Armour-Thomas, E. (1998). Mathematics teaching as problem solving: A framework for studying teacher metacognition underlying instructional practice in mathematics. Instructional Science, 26, 5-25.
Aydin, F. (2011). Geography teaching and metacognition. Educational Research and Reviews, 6(3), 274–278.
Baker L. (2010). Metacognition. In P. Peterson, E. Baker & B. McGraw (Eds.), *International encyclopedia of education* (3rd ed., pp. 204-210). Oxford: Elsevier
Beyer, B. (2000).What research suggests about teaching thinking skills. In A. Costa (Ed.), Developing minds: A resource book for teaching Thinking (pp.275 -286). Alexandria, VA: Association for Supervision and Curriculum Development.
Bowie, L., Chiyaka, M., Finch, F, Mulenga, S., (2015). *Progress in Mathematics Grade 11: Oxford: Teachers' Hand Guide.* Oxford University Press, ORBIS (Pty) Limited.
Braun, Virginia; Victoria Clarke (2006). "Using thematic analysis in psychology". Qualitative Research in Psychology. 3 (2): 93.
Carlson, M. P., & Bloom, I. (2005). The cyclic nature of problem solving: An emergent multidimensional problem-solving framework. *Educational Studies in Mathematics, 58*(1), 45-75. doi:10.1007/s10649-005-0808-x
Carr, M., Alexander, J., and Foldes-Bennet, T. (1994). Metacognition and Mathematics Strategy Use. Applied Cognitive Psychology. Vol. 8, 583-595.
Chamot, A. U. & O`Malley, J. M. (1994). TheCALLA handbook: Implementing the cognitive academic language learning approach.White Plains, NY: Addison Wesley Longman.
Creswell, J.W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches. Third Edition. Thousand Oaks: Sage Publications Inc.
Curwen, M. S., Miller, R. G., White-Smith, K. A., & Calfee, R. C. (2010). Increasing teachers' metacognition develops students' higher learning during content area literacy instruction: Findings from the read-write cycle project. Issues in Teacher Education, 19(2), 127–151.
Desoete, A., Roeyers, H. & Buysse, A. (2001). Metacognition and mathematical problem solving in grade 3. Journal of Learning Disabilities, 34, 435-449.
Doganay, A., & Ozturk, A. (2011). An investigation of experienced and inexperienced primary school teachers' teaching process in science and technology classes in terms of metacognitive strategies. *Educational Sciences: Theory & Practice, 11*(3), 1320-1325. Retrieved from http://files.eric.ed.gov/fulltext/EJ936314.pdf
Esterhuyse, A. (2015). African Journal of research in mathematics, science and technology education. A. Esterhuyse faculty of military science (military academy). Metacognition and learning 1556- 1623, 1556-1631.
Examination Council of Zambia, ECZ. (2015). *Examinations Council of Zambia*. Lusaka.
Fisher, R. (2007). Dialogic teaching: Developing thinking and metacognition through philosophical discussion. Early Child Development and Care, 177(6–7), 615–631.
Garofalo, J., & Lester, F. K. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education*, *16*(3), 163-76. doi:10.2307/748391.

Geiger, V., & Galbraith, P. (1998). Developing a diagnostic framework for evaluating student approaches to applied mathematics. International Journal of Mathematics, Education, Science, and Technology, 29, 533-559.

Georghiades, P. (2004). From the general to situated: Three decades of metacognition. International journal of science education, 26(3), p. 365- 383.

Goos, M., Galbraith, P., & Renshaw, P. (2002). Socially mediated metacognition: Creating collaborative zones of proximal development in small group problem solving. *Educational Studies in Mathematics, 49*(2), 193-223. doi:10.1023/A:1016209010120

Guest, Greg (2012). Applied thematic analysis. Thousand Oaks, California: Sage.

Hennessey, M. G. (1999). Probing the dimensions of metacognition: Implications for conceptual change teaching-learning. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, MA.

Kramarski, B., Mevarech, Z. R., & Arami, M. (2002). The effects of metacognitive training on solving mathematical authentic tasks. *Educational Studies in Mathematics, 49*(2), 225-250. doi:10.1023/A:1016282811724.

Lantolf, J. P. & Poehner, M. E. (2013). The unfairness of equal treatment: objectivity in L2 testing and dynamic assessment. Educational Research and Evaluation, 19(2-3), 141-157. doi:10.1080/13803611.2013.767616

Larkin, S. (2010). Metacognition in young children. New York: Routledge.

Lester, F. K. (1994). Musings about mathematical problem solving research: 1970-1994. Journal for Research in Mathematics Education, 25 (6), 660-675.

Lindblom, J. & Ziemke, T. (2003). Social Situatedness of Natural and Artificial Intelligence: Vygotsky and Beyond. Adaptive Behavior, 11(2), 79-96. doi:10.1177/10597123030112002

Lisa, M. G. (2008). The Sage Encyclopaedia of Qualitative Research Methods. Sage: Thousand London: Routledge.

Ministry of Education, (2009). *School-Based Continuing Professional Development (SBCPD) Through Lesson Study: teaching skills book, JICA.*

Ministry of Education, Science, Vocational Training and Early Education (2013). "O" Level Mathematics Syllabus (Grades 10 to 12). Curriculum Development Centre, Lusaka.

Newton, R.R (2001). *Surviving your dissertation: A comprehensive guide to content and process (2nd ed.).* Thousand Oaks: Sage.

Okoza, J., & Aluede, O. (2013). Understanding metacognitive awareness among teachers in the school system: Issues and benefits. Inkanyiso: Journal of Humanities and Social Sciences, 5(1), 64-71. Retrieved from http://www.ajol.info/index.php/ijhss/article/view/94070.

Papaleontiou-Louca, E. (2003). The concept and instruction of metacognition. *Teacher Development*, *7*(1), 9-30. doi:10.1080/13664530300200184

Patton, J. (2015). *Qualitative research and Evaluation methods (3rd Ed.).* Thousand Oaks,

Pieterse, S. M., (2014). Teachers' Mediation of Metacognition during Mathematical problem solving: Thesis for the degree of masters' education in educational support university of Stellenbosch; South Africa. Hove, UK: Psychology Press Ltd.

Retrieved from http://www.ajol.info/index.php/saje/article/view/44145

Schoenfeld, A. H. (1985). *Mathematical problem solving*. Orlando, FL: Academic Press.

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189- 215). New York: Lawrence Erlbaum Associates.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. A. Grows (Ed.), Handbook of research on mathematics teaching and learning (pp. 334-370). New York: MacMillan.

Schoenfeld, A. H. (2010). *How we think: A theory of human decision-making with educational applications.* New York: Routledge.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review*, *7*(4), 351-371. doi:10.1007/BF02212307.

Siyepu, S. (2013). The zone of proximal development in the learning of mathematics. South African Journal of Education, 33(2), 1-13. Retrieved from http://www.ajol.info/index.php/saje/article/download/88410/78022.

Stephan T. & Kotze, G. (2009). Metacognitive Strategies in the Teaching and Learning of Mathematics. Pythagoras, 70, 57-67 (December 2009)

Suter, W. N., (2012). *Introduction to educational Research: A critical thinking approach (2nd ed.).* Thousand Oaks, CA: SAGE Publications.

UNESCO (2014). *EFA Global Monitoring Report 2013/14*.

Van der Walt, M. S., & Maree, J. G. (2007). Do mathematics learning facilitators implement metacognitive strategies? South African Journal of Education, 27(2): 223-241.

ISSN 2222-1735 (Paper) ISSN 2222-288X (Online) DOI: 10.7176/JEP
Vol.10, No.15, 2019

Victor, A.M. (2004). *The Effects of Metacognitive Instruction on the Planning and Academic Achievement of First and Second Grade Children. (Doctoral Thesis*). Chicago, IL: Graduate College of the Illinois Institute of Technology.
Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.
Wilson, J. W., Fernandez, M. L., & Hadaway, N. (1993). Mathematical problem solving. In P. S. Wilson (Eds.), R*esearch ideas for the classroom: High school mathematics* (pp. 57-78). New York: MacMillan.
Wilson, N. S., & Bai, H. (2010). The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition. Metacognition and Learning, 5, 269–288. https://doi.org/10.1007/s11409-010-9062-4.
Xiao, Y. (2007). Appling metacognition in EFL writing instruction in China. Reflections on English Teaching, 6: 19-33
Zhang, Y., & Wildemuth, B. M. (2009). Qualitative analysis of content. In B. M. Wildemuth (Ed.), Applications of social research methods to questions in information and library science (pp.308-319). Westport, CT: Libraries Unlimited.
Zimmerman, B. J. (2002). Becoming a self-regulated learner: An Overview. *Theory into Practice*, *41*(2), 64–70. https://doi.org/10.1207/s15430421tip4102

Table 1: Sample of metacognitive strategies interviews

METACOGNITIVE STRATEGIES — PARTICPANTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CLARIFYING LEARNERS		X					X					X	X					X			X								X	X
PROBLEM SOLVING ACTIVITIES	X					X	X					X	X	X					X		X							X	X	
CORPORATIVE LEARNNING	X	X				X	X			X	X	X				X		X				X								
GENERAL QUESTIONS		X			X	X	X				X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X
CHOOSING CONSCIOUSLY		X			X	X	X			X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	
REFLECTING, PARAPHRASING AND EVALUATING LEANERS' IDEAS		X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	
IDENTIFYING DIFICULTY	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X
PLANNING STRATEGY	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
EVALUATING WAYS OF THINKING	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TALKING LOUD	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
JOURNAL KEEPPING	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

KEY:

☐ Metacognitive strategies used by leaners

X Metacognitive strategies not used by leaners

Table 2: METACOGNITIVE STRATEGIES CHECKLIST

Metacognitive strategy	Frequency
Clarifying learners' terms	22
Problem solving activities	20
Cooperative learning	20
Generating questions	10
Choosing consciously	08
Integrating technology	07
Reflecting, paraphrasing and evaluating leaners' ideas	05
Identifying difficulty	03
Planning strategy	03
Evaluating ways of thinking	02
Journal keeping	01

Table 3: Sample of Metacognitive strategies used by learners: Codes, Categories and Themes.

Codes	Categories	Themes
Sharing ideas in groups Keeping a journal Thinking consciously Asking from others Experiencing difficulties Understanding the problems Solving problems Trying to figure it out myself. Expressing thoughts verbally Jumping topics Keeping quiet Embarrassing you	Metacognition strategies	Metacognition skills
Own initiative Doing it alone home Jotting down points Writing a study time table Recalling what was taught Bringing everything to class Learning experiences Analysing critically what is learned Trying to figure myself out Going through the work given Studying hard	Self- reflection	
Following examples Making sense of what is difficult Putting everything in place Checking what is in place Working so well/ Working so fast Keeping quiet Not completing what is given Consulting others who know math Don't know teachers' thinking Studying hard	Self- questioning	Self- communication
Difficulty to understand everything Depending on teacher for everything Finding math difficulty Knowing what is easy and difficulty Finding math easy Don't think consciously No other platform Thinking all is right/correct Going through alone Passing with good grades always Insisting to do	Self- reinforcement	
Understanding some topics Studying hard Getting above 60% Bringing everything to class Solving on time Getting a job Passing the exams covering the work Knowing what is easy/difficult Handing in books always Changing behaviour to pass exams	Setting goals	