EXPLORING CONCEPT MAPS FOR MEANINGFUL TEACHING AND LEARNING OF

MATHEMATICS IN GRADE 6

M.ED (MATHEMATICS EDUCATION)

M B MAMPANE

2013

EXPLORING CONCEPT MAPS FOR MEANINGFUL TEACHING AND LEARNING OF MATHEMATICS IN GRADE 6

by

MARUNGWANE BATSEBA MAMPANE

MINI RESEARCH DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION

in

MATHEMATICS EDUCATION

in the

FACULTY OF HUMANITIES

(School of Education)

at the

UNIVERSITY OF LIMPOPO

SUPERVISOR: Dr. Kwena Masha

2013

DECLARATION

I declare that the mini-dissertation submitted to the University of Limpopo, for the degree of Master of Education in Mathematics Education has not previously been submitted by me for a degree at this or any other university; that it is my own work in design and execution, and that all material contained herein has been duly acknowledged.

Marungwane Batseba Mampane (Mrs)

Signed…………………………….. Date

DEDICATION

This mini dissertation is lovingly dedicated to my husband Ngwato, and children Tšhitšadi, Gafela, Hunadi, and Phaahle

ACKNOWLEDGEMENTS

I am deeply thankful to my Creator who protected me thus far. Through His Grace I was able to reach my destination (Psalm: 23).

I would like to acknowledge the support, inspiration and guidance of my supervisor, Dr. Kwena Masha. I never thought I would finish this research but due to your patience, tolerance, advices, comments, though harsh at times like 'we are trucks' pushed me to work hard and complete the work. You sacrificed the quality time of your family and took us to Silver Mist for a writing retreat. Through you I understood what it takes to do a research. May God bless you for your long-hearted character!

To Dr. Satsope Maoto I say thank you for your openness, support and encouragement.

To Dr. Kabelo Chuene, taking me through the research proposal was not an easy task. You knew where you were taking me to. Completion of proposal lightened the workload for my research.

I want to express gratitude and deepest appreciation to my parents, Phaahle and Tšhitšadi. You opened my eyes to the world. Your unwavering support made me who I am today.

My thanks also go to my in-law parents, my late father-in law Gafela and Hunadi. You looked after my kids during my absence and were always behind my progress.

I would not have completed my studies had it not been the love and support of my husband Ngwato and children. Looking after the family is an enormous task. You are caring and understanding. Keep up the good spirit. To my children, let my undertaking be an eye-opener to you. Your respect played a pivotal role during my studies especially when you assisted me with technological skills.

My special thanks to my brother Malope and his wife Meladi who were always by my side throughout this journey. Your words of encouragement will never fade away.

Special thanks to my colleagues, especially Mogotladi for support for the period of my study. You cared for me even during hard times of my health.

I would also like to acknowledge Mr & Mrs Pat Theodrine Kgomo who facilitated my research by sharing their home with me when I needed a place to stay to ease access to the institution.

I also want to express gratitude to the Circuit Manager for recommending approval of my study leave.

Thanks to the principal of my school for granting me permission to conduct the research at the school. I extend my gratitude to my fellow colleagues at the school for support and encouragement. To learners as well, your cooperation made it possible for me to complete my research.

ABSTRACT

This study used case study design to explore concept maps for meaningful teaching and learning of mathematics in Grade 6 class. The purpose of the study was to reflect on the usage of concept maps to promote meaningful teaching and learning of mathematics in Grade 6. Eighty seven (87) learners participated in the study. Data were collected through transcripts of learners' work and interviews. Interviews were conducted to get more information on learners' concept maps. Learners drew concept maps on three different sessions on different topics namely: fractions, measurement and angles. A list of concepts was supplied for each topic. 10 learners' concept maps and 2 interview transcripts were analysed. Mark schedules were also used to check learners' performance. Results showed that learners used varied number of links to connect concepts and that there was an increase in the number and quality of propositions made. Concept maps proved to be useful in enhancing meaningful teaching and learning of mathematics in Grade 6 class.

Table of Contents

CHAPTER 1: INTRODUCTION AND BACKGROUND

Overview

Conducting a study of this magnitude has been a challenging experience for me especially that I was still a novice. Amongst others, more challenging was data analysis and literature review.

In this chapter I give the background and rationale for the study, a brief exposition of research conducted on concept mapping, the definition of a concept map, guidelines on constructing a concept map, statement of the problem, purpose of the study and the research questions.

Background and rationale

Meaningful teaching and learning has been a concern in education since the birth of transformation in South Africa. Prior to this era teaching and learning of mathematics was sometimes based on generalised contention of memorisation of facts and examination oriented with little emphasis on promoting understanding. It is for this reason that the South African new curriculum seeks to create a lifelong learner who is confident, literate, numerate and multi-skilled (DoE, 2002). It further points out that assessment should ensure that learners integrate and apply learnt skills. Change in curriculum would logically inform change in methods of teaching and learning. The current curriculum advocates for learner-centred teaching where learners become actively involved in the classroom situation. The teacher becomes the facilitator and not the disseminator of knowledge.

As an experienced mathematics teacher, I realised that learners still learn mathematics concepts in isolation especially in the primary phase. This has a potential to lead to poor foundation of mathematics learning that could impact negatively on higher classes. For example learners do not see that physical quantities are related to measurement, other forms of money can be expressed as fractions etc. Thus poor foundation in mathematics compelled the National Department of Education in South Africa to embark on foundations for learning campaign which stresses the importance of mastery of basic skills in reading, writing and arithmetic. The project began in 2008 where learners write common examinations nationally in languages and mathematics in Grades 3 and 6. Results for 2010 academic year as documented by the Department of Basic Education in the report on the Annual National Assessments of 2011 showed that much work should still be done in making learners master those skills. Learners that are currently in Grade 6 had already been exposed to such common assessment but they still underperform. One of the reasons could be that learners learn mathematics concepts in isolation because they still find difficulties in connecting mathematics concepts even if they had been taught those concepts in previous grades. Such learning results from what Afamasaga-Fuata'i (2011) refers to as 'shallow teaching'. She continues to say that more than shallow teaching is needed for students to build on their cognitive structures and deepen their understanding of the interconnections between mathematics concepts. Ausubel, Novak and Hanesian (1978) share the same view by stating that rote learning is arbitrary, verbatim and non-substantive while meaningful learning is non-arbitrary, non-verbatim, substantive incorporation of new ideas into learner's framework of knowledge.

This concern of quality learning of mathematics is not peculiar to South Africa only but to other countries as well. For example, in Australia, the Australian Association of Mathematics Teachers (2006) identified the need for knowledge of conceptual understanding as essential to achieve excellence in mathematics teaching. Teachers, as Hough, O' Rode, Terman and Weissglass (2007) postulate, are key figures in changing the ways in which mathematics is taught and learned at school. It is against this background that I decided to conduct a study on exploring concept maps for meaningful teaching and learning of mathematics in Grade 6. Numinen and Itkonen (2008) point out that mathematics is grounded on precise concepts that are further based on more elementary concepts, formally linked definition-proposition-proof-chains. As a result understanding mathematical concepts is fundamental.

Concept maps are hierarchical representation of knowledge, through concepts, with linking words connecting concepts that are related. It was therefore my belief that the adoption of concept maps would enhance meaningful teaching and learning in mathematics domain. Haiyue and Yoong (2010) point out that, mathematics concepts are logically connected and I would add, should be taught and learnt as such.

Meaningful teaching means that teaching is not examination oriented but ensures that knowledge is retained after instruction (Novak, 2010). As a result, teaching should be learner-based. That is, learners should engage in activities that would demand their own experiences, understanding and creative thinking. Novak (2010) adds that in meaningful learning, the learner chooses to integrate new concepts and propositions with existing relevant ideas in his/her cognitive structure. Learners should not be passive recipients of information. In this way knowledge gained would be easily transferred both within the domain and across the curriculum (Scagnelli, 2002). Meaningful learning as Scagnelli (2002) asserts, refers to connecting new learning to an existing framework of knowledge.

Defining a concept map

According to McGowen and Tall (1999) a concept map is a diagram representing the conceptual structure of a subject discipline as a graph in which nodes represent concepts and lines connect and represent cognitive links between them. González and Novak (1993) view a concept map as a visual representation of the hierarchy and relations among concepts within an individual mind. Again, Novak and Canas (2008) define a concept map as a graphical tool for organising and representing knowledge. Other authors though defining concept maps in other forms display a common element of concept maps as representations of concepts to show their relationship (van Boxtel, van der Linden, Roelofs and Erkens, 2002 and Bolte, 2006). The following are key elements of a concept map: concept(s), linking word(s) and proposition(s). Novak and Canas (2008) define these components as follows: a concept is a perceived regularity in events or objects or record of events or objects designated by a label. Concepts are usually enclosed in boxes. The label may be a word or a symbol. Linking words are words which connect two concepts and specify the relationship between those concepts. A proposition is a statement about an object or event in the world either naturally occurring or constructed. Propositions are also called units of meaning.

I aligned my study with the definition by Gonzalez and Novak (1993) because it includes explicit representation of relationships between concepts in the form of a structure within an individual's mind. In this research learners drew own individual concept maps.

Constructing a good concept map

Concept maps structures are dependent on the context in which they would be used. It was therefore important that firstly I identified a particular problem or question that one was trying to understand. The focus question creates a context that will help to determine the hierarchical structure of the concept map (Novak and Canas, 2008). In this research the focus questions were on fractions, measurement and quadrilaterals. I identified key concepts that applied to the domain usually about 15 to 25 concepts. Concepts were listed in the parking lot. Learners were not limited to the concepts provided in the list. They could add new concepts which they considered relevant to the topic.

Statement of the problem

Learning mathematics concepts in isolation results in no or less retention of concepts which implies that meaningful learning did not take place. Concept maps are some of the strategies that can be used for meaningful teaching and learning of mathematics.

Concept maps have the potential to enhance teaching and learning of mathematics and consequently could improve mathematics performance.

Purpose of the study

The purpose of the study was to reflect on the usage of concept maps to enhance meaningful teaching and learning of mathematics in grade 6. The idea was to find ways in which concept mapping could be used as a tool that affords learners an opportunity to establish integrated ways of experiencing mathematical concepts that they learn.

Research questions

The research intended to respond to the following questions:

- What kinds of interconnections do learners make in constructing concept maps? In this question I am interested in finding whether learners would make connections, if the connections made are meaningful in relation to the topic and further more I wanted to see if learners could integrate concepts.

- Is the nature of a concept map learners produce, reflective of their performance? Here my intention was to find if there is any relationship between the nature of concept maps learners produce and the general performance of that particular learner in mathematics. Ideally, I would expect a learner who has a rich concept map to perform better in mathematics. By a rich concept map I mean a concept map that contains most concepts with meaningful and relevant connections.

Concept maps are a particular form of representation of ideas in relation to others. Knowing how learners' preferred forms of representing the ideas relate with their performance will be helpful.

Significance of the study

This study will contribute to primary school mathematics teachers as an alternative strategy to improve the teaching and learning of mathematics and consequently enhance deeper understanding of the subject. Issues raised from the study also provide baseline for evaluation of the impact of the new curriculum in relation to the promotion of lifelong and meaningful learning. And, as for myself, the study provided me with valuable experience of conducting an extended research project.

The structure of the report

The structure of the research report is as follows: In the first chapter I gave the background of the study and rationale thereof, the statement of the problem, significance of the study, purpose of the study and the related research questions. A brief introduction of the literature was also outlined in this opening chapter. The second chapter focused on the literature reviewed in relation to the study and the implication other studies had on my research. In the third chapter I reflected on and provided the study's research methodology. The fourth chapter detailed the findings and discussions of the research and in the fifth chapter I gave reflections, conclusion and recommendations.

Conclusion

This chapter highlighted the background and rationale of the study, statement of the problem, significance of the study, purpose of the study and the research questions. The next chapter focuses on review of literature.

CHAPTER TWO: LITERATURE REVIEW

Overview

My approach to literature review was as follows: Numerous texts were identified with a view of defining Concept Maps, outlining individual studies that used Concept Maps for various purposes in each case indicating how that relates to the current study with the aim of identifying gaps and showing the need for my study, and finally addressed the theory underpinning the study.

Meaningful teaching and learning

Teaching and learning are among the five elements of knowledge advocated by Novak (2010). These two are inseparable and interdependent to each other especially in a classroom context. Where there is teaching there is learning. Teaching means imparting knowledge to someone who is less or not knowledgeable in a particular domain while learning according to Wikipedia, refers to acquiring new, or modifying existing knowledge, behaviour, skills, values or preference and may involve synthesizing; involves an appropriate interaction of new knowledge (new concepts) with the learner's existing or prior knowledge and is long lasting. Dreyer (2008) uses the phrase 'effective teaching' to refer to meaningful teaching. She explains that effective teaching facilitates meaningful learning. Tyler (2009) claims that meaningful teaching is more than just parlaying knowledge to students. Instead, meaningful teaching involves finding out what works for your students and trying different techniques that will enable them succeed in their lives (National Board for professional Teaching Standards, 2004; in Tyler 2009)

Scagnelli (2002) defines meaningful learning as connecting new learning to an existing framework of knowledge. Learning is not limited to the presence of the educator imparting knowledge to the learner. Learning can still take place from other support material like TV programmes and textbooks without the aid of a teacher. Meaningful learning according to Boo and Hoh (2001) involves the appropriate interaction of new knowledge and is long-lasting. They also refer to meaningful learning as deep learning and rote learning as superficial learning.

Meaningful learning, Dreyer (2008) argues, occurs when new experiences lead to remembering more effectively, when words are assimilated into existing knowledge framework and when feelings influence the long-and short-term memory. She points out that individual learning approach and the intervention by the teacher comprise meaningful learning. According to Novak (2003) there are three requirements for meaningful learning which are: prior knowledge, meaningful material (selected by the educator) and student' choice to learn. The student chooses to learn by becoming actively involved.

Various studies investigated the use of concept maps as teaching and learning tools (Maas & Leauby, 2005); as evaluation tools (Pedro et al., 2000; Williams,1998); Mwakapenda, 2003; 2005), as research tools (Williams, 1995) and as communication tools (Afamasaga-Fuata'i, 2007) in mathematics and in other disciplines.

Kinchin (2000) shows that concept maps have been widely used both to promote and measure meaningful learning in other fields especially in science teaching and in medical science like the study conducted by Nasrabadi and Yekta (2004). Kinchin (2000) further points out that concept maps have been applied in a variety of context e.g., in teacher education (Schimittau, 2004) and evaluation of students' misconception or conceptual change (Canas and Reiska, 2008).

The use of concept maps as a tool that facilitates meaningful teaching and learning is a relatively new conquest Haapala et al. (2000). Here follows some of the studies conducted.

Studies that used Concept Maps

Novak (2003) conducted a research in science field on concept mapping as the promise of new ideas and new technology for improving teaching and learning. The research was a 12-year longitudinal study where the researcher used concept maps in instruction and in assessment. Participants were Grades 1 & 2's. There were those who used concept maps and those who did not use concept maps. He believes that for the learner to reach high levels of meaningful learning, some prior relevant knowledge structures are built.

Novak's research involved interviews of 1 student over a period of 12 years. Findings revealed that there was a great change in conceptual understanding for children who used concept maps and little or no gains for those who persisted in rote learning. In his research I found the link with my study on meaningful learning as Novak contrasts meaningful learning with rote learning. According to Moreira (2011) rote learning emphasizes the storage of knowledge in a verbatim way, with no interaction with prior knowledge, no grasping of meanings, no retention, and no transfer skills while meaningful learning stands for learning with meaning, comprehension retention and transfer skills. Stoica, Moraru and Miron (2011) add that meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already acquired. Thus concept maps proved to be useful in promoting meaningful teaching and learning.

Another study was conducted by Afamasaga-Fuata'i (2007) on concept mapping with Samoan university students enrolled in a research mathematics course. Concept maps and vee diagrams were introduced as a means of learning mathematics more meaningfully and solving problems more effectively. Content included limits and continuity indeterminate forms, numerical methods, differentiation, integration and complex analysis. Data collected consisted of students' progressive concept maps (4 versions) and progressive vee diagrams of 3 problems (2 versions per problem), and final reports. The researcher was meeting students twice a week for 50 minutes each time over 14 weeks. Results showed that there was a marked shift from simply providing formulas, procedural steps, excessive illustrative examples, and entire paragraphs to seeking more integrated and differentiated conceptual interconnections which reflected the impact of the social interactions on an individual's evolving understanding. The results according to Afamasaga-Fuata'i (2007) implied that the concurrent use of concept mapping and social critiques within the mathematics classrooms has the potential to promote the development of mathematical thinking, reasoning, and effective communication which are most desirable skills to succeed in mathematics learning. Integrated and differentiated conceptual interconnections relate to my research in that they respond to my research questions.

Scagnelli (2002) did an action research on the effects of computer - assisted concept mapping with two third grade teachers on learning, retention,; and transfer of knowledge. The aim of the study was to promote meaningful learning so that all students can perform to the best of their ability. Observations and test were the methods used to collect data. Participants were one third grade classroom teacher and the school's Technology Specialist and students from two third grade science classes. Students were randomly assigned to homogeneous classes. 15 students remained in the experimental group while 28 were in the control class. The instructional Technology Specialist designed how concept mapping could be used to enhance instruction of the content provided by the classroom teacher.

Students constructed concept maps before, during and after instruction. Concept maps drawn were on the concept, heat. In the experimental class the teacher used concept map as illustrations during instruction. All other instructional materials were the same for both classes. Data was analysed using rubric. Student learning from concept maps showed a steady increase in the quality and quantity of the information on the concept maps. Even if the study was conducted using software, I still found it relevant in my research, especially with regard to the second research question. Of utmost importance is the impact that concept maps had on students' learning. The quality of learning that took place implies that meaningful learning took place which resulted from meaningful teaching. To support this idea Scagnelli (2002) asserts that concept mapping as an instructional strategy has recently been widely used due to the development and distribution of popular concept mapping software applications. The quality of connections made by students relate to my research.

As an educational strategy to promote meaningful learning Nasrabadi and Yekta (2004) researched with 205 fourth year nursing students who were doing Nursing Bachelor's The purpose of the study was to determine the effects of teaching by concept mapping method on meaningful learning of students pursuing a nursing bachelor degree program. Participants were divided into two groups namely intervention and control groups. The two groups were taught differently. The selected material (intervention group) was taught by concept mapping while in the control group the researcher applied the traditional lecture method. Results showed that teaching based on concept mapping is effective on learning method and information retention. I found this study relevant to my research with regard to its purpose.

Concept mapping was not only applied with students but was spread even in teacher education. This is evident on case study research conducted by Schimittau (2004) when she examined concept maps of two pre-service teachers to illustrate the potential of concept mapping to the teacher educator. She decided to undertake the study as she realized then that concept mapping in mathematics was being underutilized in the US. In her article Schimittau (2004) does not reflect how the participants were selected but it is indicated that the two participants were a male and a female. The participants were given a task to draw concept maps to show their understanding of the concept of multiplication. This activity followed extensive class discussion of the concept map. The concept maps were then analysed and the findings showed that the two participants did not have the same understanding of the concept of multiplication. Teacher A (female) reflected relevant content knowledge and pedagogical content to teach the concept with meaning. Her map showed a real understanding of the conceptual connections the researcher presented in the class. According to Schimittau (2004), a teacher who possesses these understandings is in good standing to expand the topic to even multiplication of complex numbers. On the other hand, the concept map of teacher B (male) showed inaccurate conceptualization. His connections were consistently formalist and gave no evidence that his teaching will go beyond a formalistic approach.

Though both students were present in the same class their concept maps revealed very different understandings of the concept. Novak (2003) emphasises that each learner must construct his/her own understanding of concepts, relationships and procedures. He goes on to point out that while peers and teachers can assist a learner in learning, the construction of meanings and understandings, together with skills is an idiosyncratic process that only each learner can choose to achieve. This in simple terms means that every learner is unique. The type of connections made on concept maps became of interest to me.

Naidoo (2006) conducted a research with Grade 11 class of 36 mathematics learners. He used concept maps to explore learners' understanding of the Function Concept. The design of the research was a case study. The study took place at Kelcay Secondary school (South Africa) where he taught for 16 years. This gave him an advantage on the setting and sample as he was familiar with them. The school is a multi-racial one with more learners from better socio-economic backgrounds and is situated in an urban area. Learners were inducted in the process of concept mapping in 2 1hour periods. They were even shown examples of concept maps. His data collection was done in two parts. The first part of the data collection process was the production of concept maps by learners. During the first concept map drawing task, learners were provided with a list of concepts: equation; zero; variables; gradient; inverse; parallel; perpendicular and function.

The second part of the process involved interviews carried out with a sample of learners based on their 'completed' concept maps. Interviews were used to identify and clarify the propositional meanings. Through interviews, learners were afforded an opportunity to reflect on the connections they made. In his analysis, Naidoo used both rubric and memorandum. No formal scoring technique was used. He only counted the number of concepts used or omitted from the list. My study features in Naidoo's research with regard to the focus on propositional meanings because they relate to my first research question. He also used interviews for data collection which I also applied in my research. Concept maps proved to be useful in improving learners' understanding of the Function Concept.

Hough, O'Rode, Terman and Weissglass (2007) used concept maps to assess change in teachers' understanding of algebra. The study was conducted in the context of a five-year National Science Foundation in USA. The setting of the study was a 10-day summer institute in which experienced teachers came to learn more mathematics content on pattern and relationships and their graphs. The study involved 29 teachers from nine school districts representing grades K-12. For data collection the researchers used concept maps drawn by the teachers. The concept maps were on algebra. Participants used lines to connect words and phrases to the central themes or to previously existing nodes. Structural or numerical and content analysis methods were used to analyse data. When concept maps were analysed structurally or numerically, it was found that the number of concepts increased and crosslinks were added. Content analysis showed that participants' knowledge on algebra grew. Participants felt that they had gained a greater understanding of concepts. What attracted me in relation to my study was how concepts were connected i.e. by using lines. Thus concept maps enhanced teachers' knowledge on algebra.

Gonzalez, Palencia, Umana, Galindo and Villafrade (2008) researched on concept maps as pedagogical tool for achieving meaningful learning in medical physiology students. Gonzalez et al. (2008) explain the pedagogical tool as a metacognitive strategy that assists learners to develop a self-appraisal of their own individual cognitive processes. They divided students in the 2:1 ratio of intervention students to control students. Students in the intervention group attended four 2 hour mediated sessions to develop an approach (concept mapping) to study their topic. Two types of examinations were given to students. They were multiple choice examinations where students had to recall precise information related to the questions and problem solving examination where students were asked to resolve specific questions using hierarchical structuring, sequencing or proposing alternatives. Qualitative analysis proved that intervention increases students' motivation and stimulates active participation in the construction of personal knowledge. Results showed that the intervention group performed better than the control group. When asked to justify the relationship between concepts, students were able to recognize and analyse distortions in their own understanding of the contents. This is in line with the interviews in my research where learners would be expected to clarify their connection. Concept maps were useful for facilitating meaningful learning in medical students.

As research tools, Grevholm (2008) conducted a longitudinal research on concept maps in mathematics education. Focus was on student teachers ’conceptual development in mathematics. The study involved 48 student teachers who were prepared to teach in school years 4-9 in Krinstiastad University in Sweden. She collected data firstly through questionnaires and interviews. Results failed the researcher to get an image of students’ perception of their own learning. Both questionnaires and interviews retrieved little of what students had in their minds about the concept function. By then concept maps had been introduced to students. Grevholm then used concept maps as an alternative method to collect data. Students drew concept maps on three different occasions over a period of 15 months. Grevholm analysed one student’s three concept maps. The maps differed in complexity showing growth in student’ understanding of the concept function. She found that concept maps gave a richer material and substantial knowledge about how students express their mental structures became available. Furthermore Grevholm (2008) found that concept maps provided multidimensional responses than linear responses in the form of sentences. Concept maps were thus used successfully as research tools.

In South Africa again Mwakapenda (2003) conducted a research on concept maps as a tool to explore 1st year university students’ understanding of key concepts in mathematics curriculum. The study took place at the University of Witwatersrand with 22 students from three different groups. Students were introduced to concept mapping and thereafter asked to construct a concept map using a list of concepts on mathematics content. When analysing concept maps, the researcher found that students’ concept maps did not include any linking words or phrases to indicate relationships between concepts. This made the researcher to conduct reflective interviews to probe students’ thinking to give student opportunities to expand and elaborate on the meanings in the links and ask them to give examples to illustrate the links. Merriam (1998) agrees with this contention when she advises that interviewing is necessary when we cannot observe behaviour, feelings or how people interpret the world around them. Some of the responses in the interviews showed what Mwakapenda (2003) refers to as compartmentalised view of mathematics. This means that students saw mathematics concepts as fragmented, disconnected and not having any relationships. Findings revealed that concept mapping provides entry into reflecting the connections.

Mwakapenda (2004) again used concept maps to understand student understanding in mathematics in terms of how they make links between concepts. In his study he involved three different groups of first year mathematics students from the University of the Witwatersrand. Participants were selected in terms of their pervious school performance and their university enrolment and settings that are often fragmented in the way they are presented in the curriculum. This is what Haapala et al. (2002) view as conceptual change in understanding concepts. For data collection he gave students a task on concept map drawing with a list of concepts provided and secondly, he used reflective interviews which were based on their concept maps. Reflective interviews according to Mwakapenda (2004) present an opportunity for students to explain and elaborate on the meanings represented in the links and again to allow them to provide appropriate examples to illustrate those links.

In data analysis, Mwakapenda did not prefer scoring concept maps because according to Novak and Musona (1991) any map scoring procedure reduces some of the richness and detail of information contained in a concept map. Results showed that students were capable of making connections between mathematics concepts. Thus concept mapping was found to be a useful tool for promoting understanding of conceptual meanings of the connections in mathematics.

It is worth noting that not all studies reviewed found concept maps more positive to improvement of learning. There are those studies that did not find concept maps as useful tools. Hasemann and Mansfield (1995) studied 25 Grade 4 and 26 Grade 6 volunteer students on concept mapping. The participants constructed concept maps on two separate occasions at 5 months apart arranging predetermined concepts on cards into groupings. The Grade 4 maps were more contexts oriented whereas Grade 6 maps were more domain oriented. The results showed that no significant difference in mapping schemes was noted between testing episodes. The researchers then inferred that no meaningful learning took place and hence concept mapping did not prove to be useful.

On the basis of the background given, I realised that though studies have been conducted on concept maps, most of them focused on concept maps as assessment tools. Furthermore most of the studies were done in other countries like United States of America (Maas & Leauby, 2005); in England (Afamasaga-Fuata'I, 2007); in Spain (Schimittau, 2004); in Greece (Baralos, 2002); and in South Africa (Mwakapenda, 2003; 2004; 2005; Naidoo, 2006). Furthermore, the studies that related to the use of concept maps for meaningful teaching and learning were done more in other fields than in mathematics especially in intermediate phase class. Those that were done in South Africa concentrated more in higher classes than in lower classes. Thus I saw the need to explore concept maps for meaningful teaching and learning with the intention to close this gap as Naidoo (2006) claim that in South Africa concept maps have just been incorporated as assessment tools. I also gained interest in the study on the following grounds as outlined by Grevholm (2008):

- Concept maps give the students better opportunities to express their concept image.
- Concept maps give richer answers with more content and several dimensions of the concept.
- Knowledge that students express through a concept map seems to be lasting.

Concept mapping is a powerful tool for the facilitation of meaningful learning Novak and Canas (2008).

The study conducted by Mwakapenda (2003) influenced my research on the following reasons: His study examined how students could and would link concepts across topics. He used concepts that were familiar to students. Mwakapenda used reflective interviews to probe into students' thinking because he realized that concept maps externalizes only a part of an individuals' thought. In data analysis, Mwakapenda did not use scoring results.

The literature reviewed in this research displayed the following: First, various ways in which concept maps were used for different purposes like; as research tool, as evaluation tool, and as a tool that promotes meaningful teaching and learning. Secondly, concept maps were used in varied domains such as mathematics, accounting, science etc. Thirdly, concept maps were used in different contexts in which the researches were conducted as in classroom context and health. Fourthly, researches were done from primary to tertiary level, and in teacher education. My research falls in the category of concept maps as a tool that promotes meaningful teaching and learning, in the mathematics domain, in primary school and in the classroom context.

Theoretical framework

The theory that guides the study is that of assimilation propounded by Ausubel (1963; 2000). He identifies the psychological and epistemological foundations of concept maps. He further points out that meaningful learning result in the creation and assimilation of new knowledge structures. Learners become creative when constructing concept maps because they use their own prior knowledge to connect the concepts. He continues to say that new concepts and propositional learning are mediated by language and occurs when new meanings are obtained by asking questions and getting clarification of relationships between old concepts and proposition and new concepts and propositions. Grevholm (2008) adds that conceptual knowledge is knowledge that is rich in conceptual relationships. In this study I examined the kinds of relationships learners made in their concept maps. I sought clarification of learners’ concept maps through interviews.

Ausubel (1963) points out that, concepts are acquired from birth to the age of three when children recognise regularities in the world around them and begin to identify language labels or symbols for these regularities. As a psychologist, he believes that learning takes place through assimilation. He shows that there are two ways of learning concepts: by concept formation and by concept assimilation. After three years, new concepts and propositional learning are mediated by language and occurs mainly by a reception learning process when new meanings are obtained by asking questions and getting clarification of relationships between old concepts and propositions and new concepts and propositions. Here I expanded on concept assimilation because the first one is common to pre-schoolers. Learners expressed themselves through language when they were responding to questions during interviews. Macnamara (in Novak and Canas, 2008) declares that a human memory is not an empty vessel to be filled but rather a complex set of interrelated memory systems. These systems are short term memory, working memory and long term memory. All incoming information is organised and processed in the working memory. This implies that learners come to class with individual experiences and knowledge that the teacher should use as a building block for the new content.

Like epistemologists, Ausubel (1963) believes that new knowledge is a constructive process involving both our knowledge and our emotions or the drive to create new meanings and new ways to represent these meanings.

According to Ausubel et al. (1978) concept map depicts four main cognitive processes namely; subsumption, progressive differentiation, integrative reconciliation and superordinate learning. She clarifies them as follows: During subsumption, learners link new specific concepts to a more general concept. Superordinate learning takes place when a new idea is relatable to specific subordinate ideas in the existing cognitive structure. Progressive differentiation claims that learning, retention and organisation of knowledge is hierarchical in nature. For differentiation learning, elaboration and clarification of meaning occurs. Integrative reconciliation manifests itself when there are similarities and/ or differences between related concepts across domains.

Conclusion

This chapter reflected on previous studies that used Concept Maps for different purposes and how they relate to my study. The next chapter details the methodology used.

CHAPTER 3: METHODOLOGY

Overview

The study was intended to explore concept maps for meaningful teaching and learning of mathematics. This study falls into the qualitative research paradigm. Merriam (1998) defines a qualitative research as a form of inquiry that helps us understand and explain the meaning of social phenomena, with as little disruption of the natural setting as possible. The role of methodology in a research process is to provide clarity with regard to study design, samples used, data collection techniques and methods, data analysis processes and ethical considerations.

The current chapter addresses the issues as raised above. It provides a snapshot of how the processes unfolded and therefore provides the context within which my research questions were pursued.

Research design

Research design is the approach a researcher uses to conduct a study. It, according to Slavin (1992), determines unambiguity such that it rules out the greatest number of alternative explanations for a particular outcome. McMillan and Schumacher (2009), define it as a plan for selecting subjects (participants), research sites (context or setting) and data collection techniques to answer the research question. Putting it the other way round, McMillan (1996) considers research design as referring to the way information is gathered from participants. I understand this broad coverage to be including how the participants are approached, forms of interactions with the participants, forms of recording, etc.

Creswell (2007) distinguishes five types of research designs in qualitative research. They are narrative, phenomenology, grounded theory, ethnography and case study. Narrative research uses a variety of analytic practices and is rooted in different social and humanities discipline. Phenomenological study describes and interprets a particular event in order to understand the participants' meanings ascribed to that event. Grounded theory study intents to discover or generate a theory that explains central phenomena derived from the data. Ethnography deals with an in-depth description and interpretation of cultural patterns and meanings within a specific culture or social group.

Case study research according to Creswell (2008) is an in-depth exploration of a bounded system (e.g., an activity, event, process or individuals) based on extensive data collection. Leedy and Ormrod (2005) add that a case study involves the conceptualization of a research problem, the investigation, interpretation of findings and their application in the world beyond the study. In this research I aligned myself with Creswell (2009) when he argues that a case study is a strategy of inquiry in which the researcher explores in depth a program, event, activity and process of one or more individuals. This is because the study focused on in-depth explorations of the grade six mathematics learners conceptualization' of concept maps. This implies that through the use of a case study I was able to understand a complex issue which ultimately made me take action. The strength of a case study, among others according to Rhee (2004) is its ability to deal with a variety of evidence collected from documents, interviews and observations. In this research I used case study as a research design because I wanted to explore concept maps for meaningful teaching and learning of mathematics by studying a group of individuals (Grade 6 learners) in a classroom (bounded system).

There are different types of case studies in qualitative research. Creswell (2007) identifies two types as single instrumental case study and collective or multiple case study. Stake (2003) has the third case study type as intrinsic case study. According to him, a case is instrumental if a particular case (single case) is examined mainly to provide insight into an issue or to redraw generalization. In this research I used single instrumental case study because only one case which is a group of grade 6 learners was studied to provide insight into an issue/theme. A single instrumental study is also referred to as theme-based study (McMillan & Schumacher (2010).

According to McMillan and Schumacher (2010) a case study can be exploratory, descriptive or explanatory. Exploratory case study as he asserts, is aimed at defining the questions and hypotheses of a subsequent study. On the other side, a descriptive case study provides narrative accounts within its context while explanatory case study presents data bearing on cause-effect relationship. In this report I did not confine myself to these narrow or compartmentalized versions of case study. Considering the uncertainties that I had with regard to the challenges of conducting this kind of study for the first time, I found comfort in remaining within the broader perspective of a case study.

The choice for case study approach was made because I wanted to learn more about what learners know or had poorly understood in certain topics like fractions, measurement and quadrilaterals. The positive aspects of a case study outlined by Bassey (1999) are that: a case study is strong in reality, recognizes the complexity and embeddedness of social truths, forms an archive of descriptive material and is a step to an action. A case study further investigates how an individual or program changes over time as a result of interventions (Leedy and Ormrod, 2005). A case study does not only portray merits but also has some demerits as others often argue that a case study when used as a single study does not justify its results (Leedy and Ormrod, 2005).

Participants and Sampling

The study involved 87 grade six mathematics learners from two classes in a public school in Mmashadi circuit of Greater Sekhukhune district. This is one of the districts in the Limpopo Province of South Africa. The school is situated in a rural setting where most learners come from impoverished families. I decided to conduct a research at this school because it was easy for me to gain access to the school as I am currently teaching at the same school. Another factor was that participants would be within reach for interviews. English is the medium of instruction at this school. The group of participants comprised 44 girls and 43 boys of average age of 12 years. I could not sample an even number of participants because purposive sampling was used. All the participants were members of the mathematics class that I teach. The study was not a separate project from the day-to-day teaching activities. I played both roles of a teacher and a researcher.

There are different major sampling techniques cited by Leedy and Ormrod (2005) namely; random and non-random sampling. Non-random sampling was used in this research. Non-random sampling is further categorized into convenience sampling, quota sampling, purposive sampling and snowball sampling. In this research I used purposive sampling. Palys (2008) describes purposive sampling as a series of strategic choices about with whom, where and how to do your research He further categorizes purposive sampling into the following: stakeholder sampling, extreme or deviant case sampling, typical case sampling, paradigmatic case sampling, maximum variation sampling, criterion sampling and theory-guided sampling to name but a few. Criterion sampling was used in this research. This type of sampling involves searching for cases or individuals who meet a certain criterion. Participants in this study were selected on the basis of performance.

In order to gain in depth rich data for the study, I chose Grade 6 mathematics learners because the study focused on teaching and learning of mathematics in the same grade. Another reason is that the study focused on some of the prescribed topics for the year which were in line with the learning outcomes to be achieved.

Data Collection

Creswell (2007) describes data collection as interrelated activities aimed at gathering good information to answer the research questions. To get insight of the research various forms of data collection techniques have to be applied to supplement each other Merriam (1998). In this research, data were collected through transcripts of learners' work and interviews to respond to the research question.

Transcripts of learners' work

Learners were first introduced to concept mapping as this strategy was unusual to them and explanations pertaining to details about it were given. Learners drew own concept maps on three sessions on different topics. This took place in the classroom. Explanation included what a concept map is, how it looks like, what are its components and the functions of those elements. For example, a concept map is a graph that shows relationships between words. The structure has the general term at the top and the specific words linked to it by means of linking lines. A list of words to be used when drawing a concept map is usually given in the word bank. One is free to add his /her own words that are related to the given topic. I showed learners how to draw a concept map on the chalkboard. The concept map was on basic operations. Related words were included in the boxes and connected by linking words such as has, like, can be, is, etc.

I indicated to learners that a concept map is not a mind map. The difference is that with concept maps the words are linked in a particular pattern whereas there is no order of how to put words in a mind map. Learners drew three concept maps at different intervals on fractions (May), measurement (August), angles (November) respectively. In each case, fifteen to twenty concepts were supplied. For the first session learners were asked to draw concept maps on fractions using fifteen concepts that were in the list. I gave them chance to show where they did not understand. Some learners rose up their hands and indicated that they are not yet comfortable with what they are asked to do. One learner said that he does not understand what a general term is. I went back to the chalkboard and explained again that a general term is like a "mother word" and all other words come from that word. The response was an 'aha!' experience. There were those who still saw a concept map as a mind map in spite of the clarification given. I encouraged them to make rough sketches first before they could draw the final one for submission. The duration for drawing concept maps was one hour for each session. Transcripts of their work were collected after each session.

Interviews

Merriam (1998) maintains that interviewing is necessary when we cannot observe behaviour, feelings or how people interpret the world around them. McMillan (1996) describes interviews as a form of data collection in which questions are asked orally and the participants' responses are recorded. He further points out that face-to-face interviews allow the interviewer to observe nonverbal responses and behaviour which may indicate the need for further questioning to clarify verbal answers. McMillan and

Schumacher (2010) and Merriam (1998) identify three types of interviews which are; structured, semi-structured and unstructured interviews.

Structured interviews

Structured interview questions give the participants choices from which an answer is selected. They are also referred to as limited response questions. They are mostly used in telephone interviews.

Semi-structured interviews

Semi-structured interviews are characterised by open-ended questions. They allow for individual responses.

Unstructured Interviews

Questions are open-ended and broad. There is no fixed order of questions. The interviewer has a general goal in mind and asks questions relevant to this goal. Unstructured interview questions are highly subjective and require thorough training and experience on the part of the interviewer. The interviewer has a general goal in mind and asks questions relevant to his goal.

I used semi-structured interviews because I could make follow-ups on individual responses. Learners were interviewed after they had drawn their second concept maps. I prepared five interview questions which were common to all learners and I recorded learners' responses through writing them on paper. The first five questions were aimed at finding if learners grasped what a concept map is and what it entails whereas the last five were based on their individual concept maps. I found that at times learners wrote what they did not mean or intend writing. In other words interviews further exposed their thinking as Afamasaga (2011) argues that learners should communicate mathematically through, among others, making connections, reasoning, justifying and reflecting. Interviews have both advantages and disadvantages as outlined by McMillan (1996) and McMillan and Schumacher (2010). Among others, interviews have the following merits and demerits:

Merits of interviews

- They increase the validity and reliability of the study
- They involve direct interaction between individuals
- Interviews are flexible and adaptable
- They result in much higher response rate than questionnaire
- They can be used with many different types of persons e.g. those who are illiterate or too young to read and write

Demerits of interviews

- They are highly taxing in terms of labour and time
- There is no anonymity because every member is exposed
- They have the potential for subjectivity and bias

Data analysis

According to McMillan and Schumacher (2010) analysis of data in qualitative research is a relatively systematic process of coding, categorizing and interpreting data to provide explanations of a single phenomenon of interest. Yin (in Creswell, 2007) distinguishes between within-case analysis and cross-case analysis in case studies. Within-case analysis refers to a detailed description of a case and themes within the case and cross-case analysis refer to a thematic analysis across the cases. In this research I used within-case analysis. I analysed three sets of ten learners' transcripts (5 boys and 5 girls) after data had been collected. During the first session learners drew concept maps using the following concepts: fractions, decimal fractions, proper fractions, money, equivalent fractions, basic operations, Lowest Common Multiple (L.C.M.), numerator, denominator, ratio, percentages, simplification, representation, Highest common factor, (H.C.F.). I chose these concepts because they covered a wider scope on Learning Outcome 1 as prescribed by the Department of Education (2002). The intention was to see whether learners could make relationships between concepts relating to fractions and not to compare scoring results. Learners' performance of four terms was also looked into using mark schedules. Results showed that improvement on performance could be noticed after learners got used to Concept Maps.

Limitations of the study

According to Pajares (2007) a limitation identifies potential weaknesses of the study. For this study I found that time allocated for explanations might not have been enough such that if more time could have been allocated, results could be affected. Concept map drawing is time consuming in itself. The sample size of this research is small and different findings could result if a larger sample was used. Furthermore the study was conducted in one school. If two or more schools were used, or if the research was conducted at circuit level, results would be different.

Delimitations of the study

I did not use a large sample size as this could affect the qualitative nature of my research. It would not be easy for me to interview a large number of participants because interviews on their own are highly taxing both in terms of time and labour. Again, on the basis of sample size I did not apply generalizability as a type of validity because of the scope and context of my study. I only confined myself to classroom context with learners that I was responsible for. Observation is another method recommended for data collection in qualitative studies. I did not apply this technique because it has high risk in bias and the participants were not unfamiliar to me and therefore data would easily be contaminated. In this research I did not use scoring method to analyse data as some researches on concept mapping did. This was because I was interested in the types of connections learners made and not the number of links they showed. Qualitative content analysis does not produce counts and statistical significance, but it uncovers patterns, themes and categories important to a social reality. In this study themes were uncovered.

Credibility of data

McMillan and Schumacher (2010) define credibility as the extent to which the results approximate reality and are judged to be accurate, trustworthy, and reasonable. He continues to say that credibility is enhanced when the research design provides an opportunity to show relationships and takes into account potential sources of error that may undermine the quality of the research and may distort the findings and conclusions. Research has shown that credibility was not applied in qualitative studies before. It has just gained credit to be applied in qualitative researches.

There are various forms of validation strategies including; prolonged engagement and persistent observation in the field, triangulation, peer review or debriefing, and member checking (Creswell, 2007). Prolonged engagement and persistent observation involves building trust with participants, learning the culture and checking for disconfirmation that stems from distortions introduced by the researcher or informants. In triangulation, the researcher makes use of multiple and different sources, methods, investigators and theories to provide corroborating evidence. Peer review provides an external check of the research process. Peer and the researcher keep written accounts of the sessions. For member checking, the researcher solicits participants' views of the credibility of the findings and interpretations. This approach involves taking data, analyses, interpretations and conclusions back to the participants so that they can judge the accuracy and credibility of the account. In this research credibility was enhanced through validity.

Leedy and Ormrod (2010) claim that validity refers to the extent to which the instrument measures what it is intended to measure. In their view validity differs according to situations. They further show the following four forms of validity: face validity which refers to the extent to which the on the surface an instrument looks like it is measuring a particular characteristic. Face validity is highly subjective. Content validity refers to the extent to which a measurement instrument is a representative sample of the content area being measured. Criterion validity is explained as the extent to which the results of an assessment instrument correlate with another. The last form of validity is the construct validity. It refers to the extent to which an instrument measures a characteristic that cannot be directly observed but is assumed to exist based on patterns in people' behaviour.

How validity was ensured

A number of strategies were used to ensure validity. In this study I used prolonged engagement, honesty of informants, thick description of the phenomenon under scrutiny and triangulation.

Prolonged engagement

I have been teaching mathematics in grade six for twelve years. This gave me an advantage of becoming familiar with the thinking of the learners.

Honesty of informants

The study was conducted in the context of everyday teaching. Learners' responded to the activities just as they would respond to any of their learning tasks. This has contributed to the enhancement of validity of the data.

Thick description of the phenomenon under scrutiny

The issues of thick description of the phenomenon under scrutiny were adequately addressed in the introductory chapter and within other sections of this current chapter. The natures of the school, the background of learners were clarified.

Triangulation

I used triangulation method to ensure validity. In this study, interviews and transcripts of learners' work were used to enhance validity. Though I did not use interviews extensively, they were not used independently of transcripts of learners' work.

Patton (2002) views triangulation as a method used by qualitative researchers to check and establish validity in their studies by analyzing a research question from multiple perspectives. Guion, David and McDonald (2011) provide five types of triangulation namely; data triangulation, investigator triangulation, theory triangulation, methodological triangulation and environmental triangulation. I used methodological triangulation because it uses multiple methods of data collection to study the program which in my case were transcripts of learners' work and interviews. These two data collection methods were used to complement each other. The disadvantage of this method is that it requires more time to analyse the information yielded by the different methods.

Participant review method was used to address reliability of the study. Participants were asked to review transcripts of their work and responses of the interview in order to modify information for accuracy. This data was then analysed for comprehensive integration of findings.

Ethical considerations

This research involved human beings and therefore I was compelled to take into account ethical considerations. Ethics as Sieber (1992) claims have to do with .the application of moral principles, to prevent harming or wrongdoing others, to promote the good, to be respectful and to be fair. This implies that the informants, which in my study were the principal, parents and learners must be accorded the utmost respect and value their dignity. Thus to make sure that my research was ethical, I addressed the following ethical categories; informed consent, right to privacy, honesty with professional colleagues and protection from harm.

Informed consent

Informed consent in research is a legal procedure to ensure that participants are aware of all the potential risks involved in the research. I requested permission from the principal of the school to conduct the research by writing a letter and explained the intention of the research. I also indicated that a summary of findings of my research would be made available and how the research would benefit the school after completion e.g., those mathematics educators may be exposed to new strategy that will enhance their teaching. The research would also benefit learners in improving their learning in mathematics and consequently their performance. The ‘myth’ that mathematics is a difficult subject would ‘fade’ away. I informed the principal that I wrote letters to parents of learners to grant permission to their children to participate in the study. It was stated in the letter that participation was voluntary and parents were at liberty to withdraw their children at any time they might feel.

Right to privacy

I guaranteed the confidentiality and anonymity of the participants including the name of the school.

Honesty with professional colleagues

I acknowledged the ideas of authors with a view of avoiding plagiarism.

Protection from harm

I ensured that the participants were in a danger free environment, be it psychological, emotional or physical.

Conclusion

This chapter dealt with the design, methods and procedures that were followed during the research. The next chapter provides details of the findings of the research.

CHAPTER 4: FINDINGS AND DISCUSSIONS

Overview

The main purpose of concept mapping in mathematics teaching is for learners to see and learn concepts not as separate entities but as integrated units both within the subject and across the curriculum. The interconnectedness of concepts becomes evident when there is correct usage of linking words, sound propositions, flow of relationships between concepts and the appropriate structure. In this chapter, focus was on issues that emerged when learners' concept maps were analyzed namely, presence and position of linking words, the structure of the concept maps and the number of concepts used to construct the maps from the given list. The presence and position of linking words indicate the relationship between concepts. The structure of concept maps identifies concept maps from other types of knowledge maps like mind-maps. Learners should be able to choose the general term and the specific terms. Through the structure one is able to read the learners' minds. For the number of concepts used; learners are at liberty to add their own concept/s as long as the concept/s is/are relevant to the topic. Findings during both pre-intervention and post–intervention sessions are reflected.

Findings

Concept maps give visual or structural relationship of the concept and its related issues or aspects. The clarity of this relationship is made by using appropriate linking words. Lack of those linking words results in an isolated approach to concepts. In reviewing the learners' responses to the request to produce concept maps, the first issue that I observed was that learners are using varying amounts of linking words. In some instances there are no linking words at all whilst in others there could be a range from few to adequate. The variations are addressed hereunder.

Concept maps with no linking words

In this category of responses, the words have generally been linked by arrows with no linking words. Out of the ten responses that I have reviewed, I found that 2 learners did not have linking words. For example, figure 1 shows a concept map drawn by Learner 2

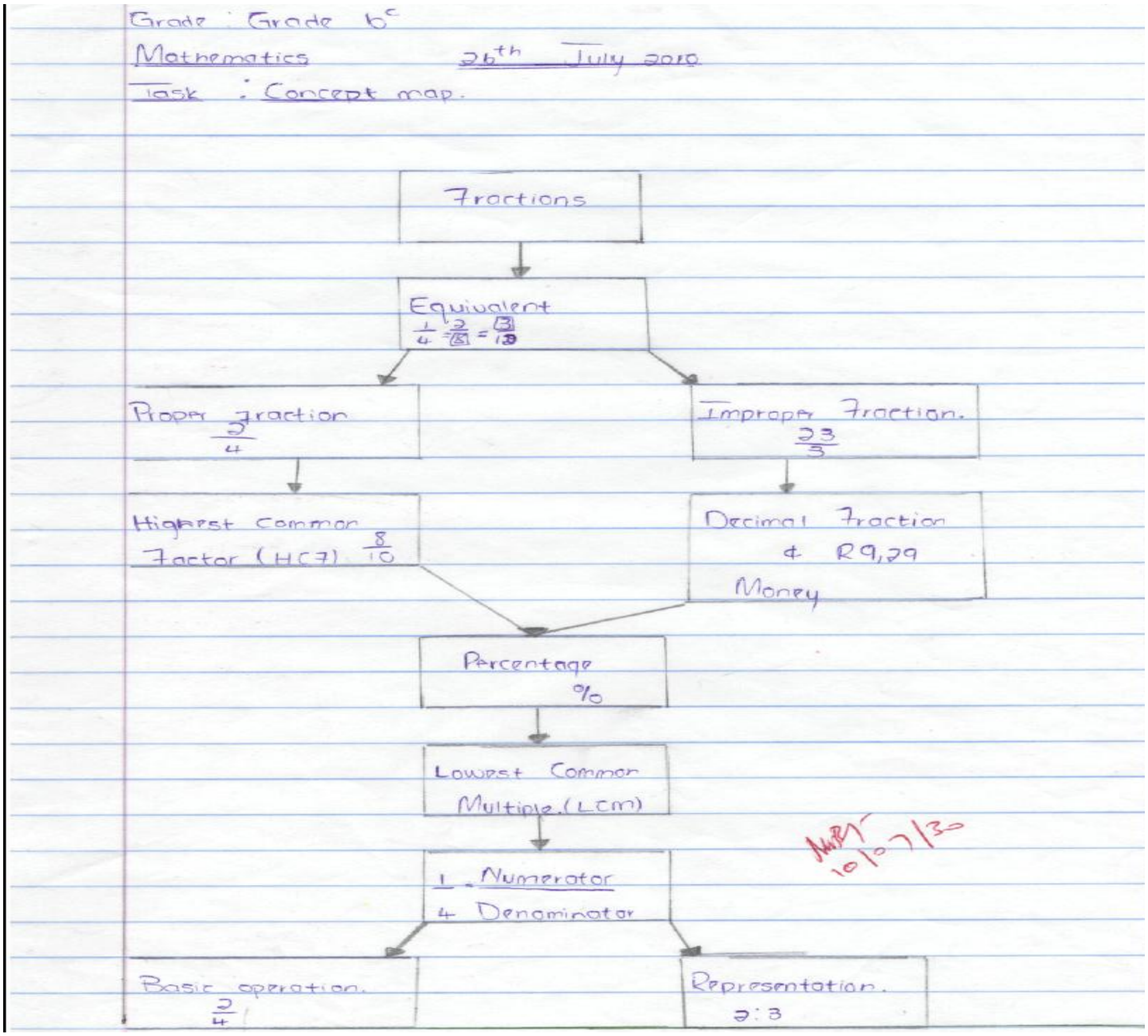


Figure 1: Learner 2 pre-intervention concept map

Generally the words are linked by lines with arrows to show the presumed relationship. Looking at the concept map the learner drew an arrow from the general term 'fraction' to 'equivalent'. Questions that might arise are: What did the learner mean by that linking line? The learner may have wished to say that equivalent fractions are included in fractions. Did the concept ‘equivalent’ define the word fractions? Are ‘equivalent’ examples of fractions? By having no linking words the aim of writing a concept map is defeated. Similarly, from the concept equivalent, there are two diversified arrows, one linked to proper fraction and the other linked to improper fraction. The questions might be: Are proper and improper fractions examples of equivalent fractions? Or are they types of equivalent factions? The relationship between equivalent fractions and improper fractions is not clear. In response to some of the questions raised above I examined Learner 9’s Concept Map on some of the linking words written as shown below.

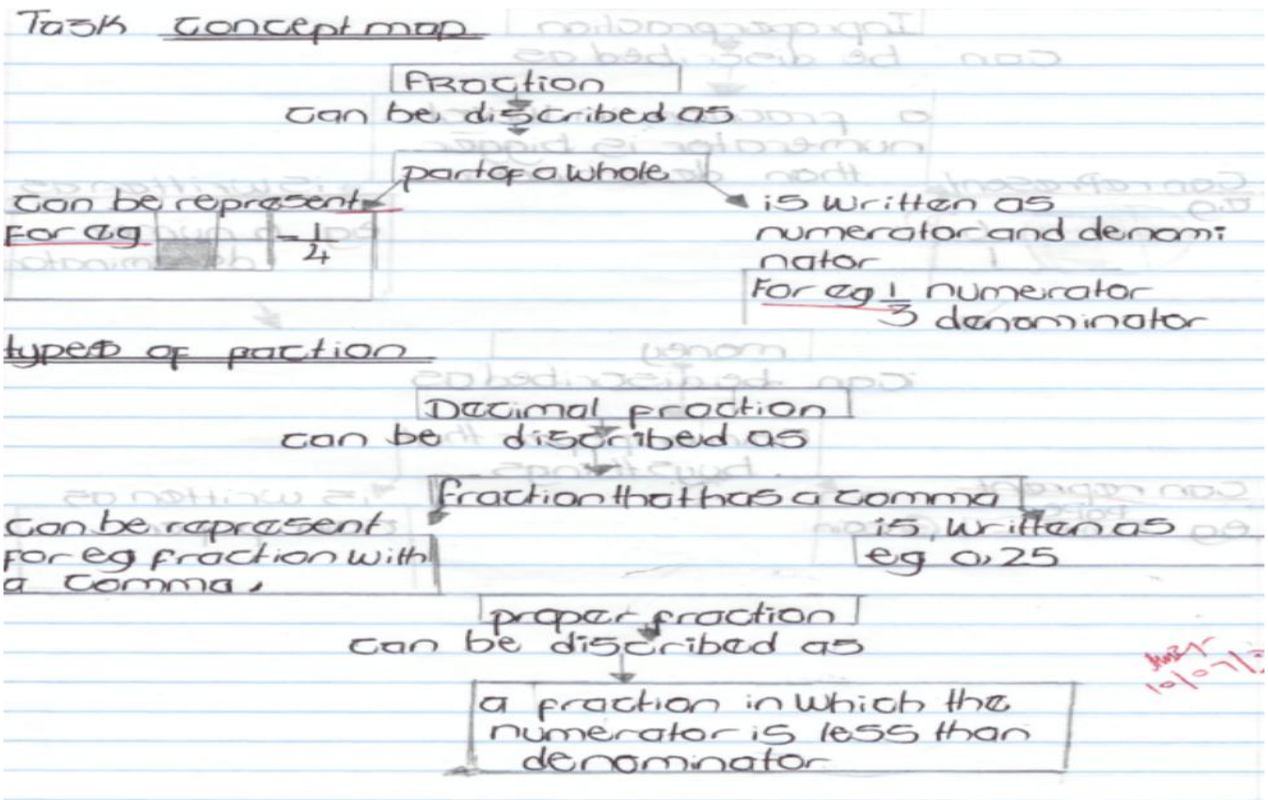
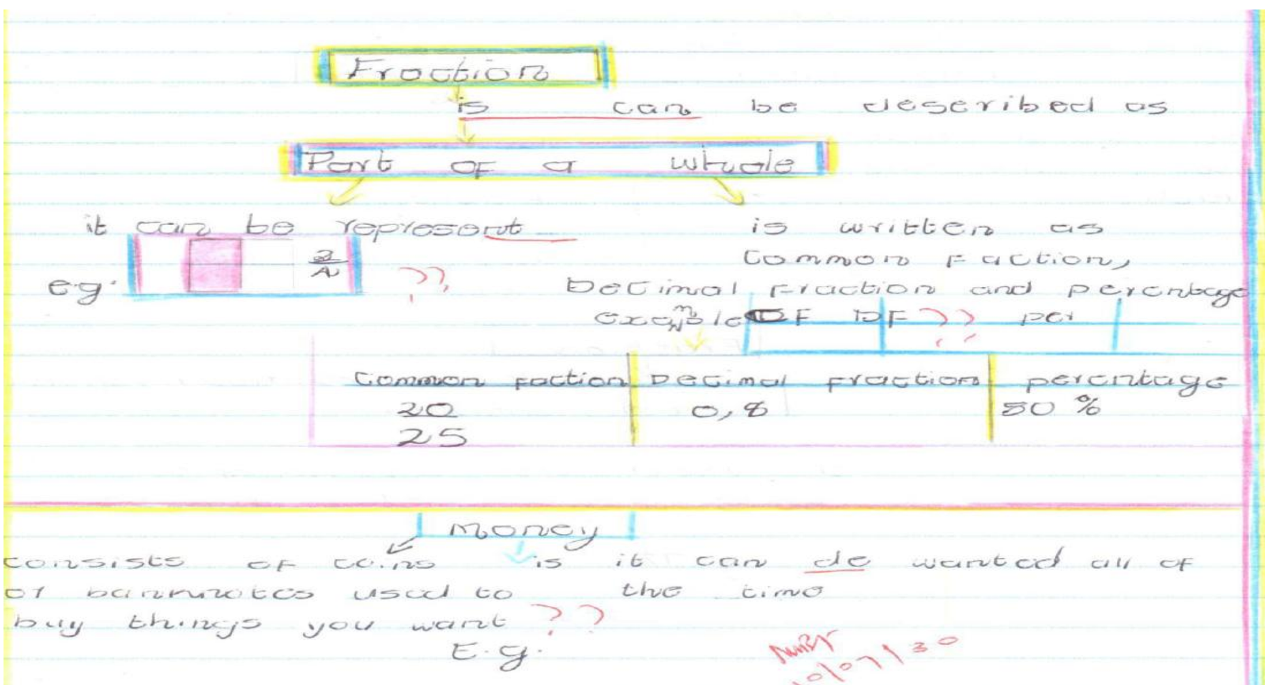


Figure 2: Learner 9 pre-intervention Concept Map

We see that the learner shows the link between the concept fraction with its description. In this way the learner clarified the relationship between fraction and part of a whole which responds to the question of what could learner 2 have meant by the linking line without a linking word.

The propositions made provide better meanings e.g., part of a whole is written as numerator and denominator (1/3) makes sense because he indicates the digits that represent the numerator and the denominator though it would sound better if the linking word ' is written as part of a whole' was placed after the fraction 1/3. Learner 7 responds to some of the questions raised by the previous concept map as indicated hereunder.

Below the concept fraction on the concept map, the learner used the linking phrase 'can be described 'and linked it to 'part of a whole'. Meaning existed because the learner gave a description or definition of the concept fraction. The learner further showed how a fraction can be represented and written through the linking phrase 'can be represent' which she meant can be represented. Most of the remaining learners used descriptive type of linking words.



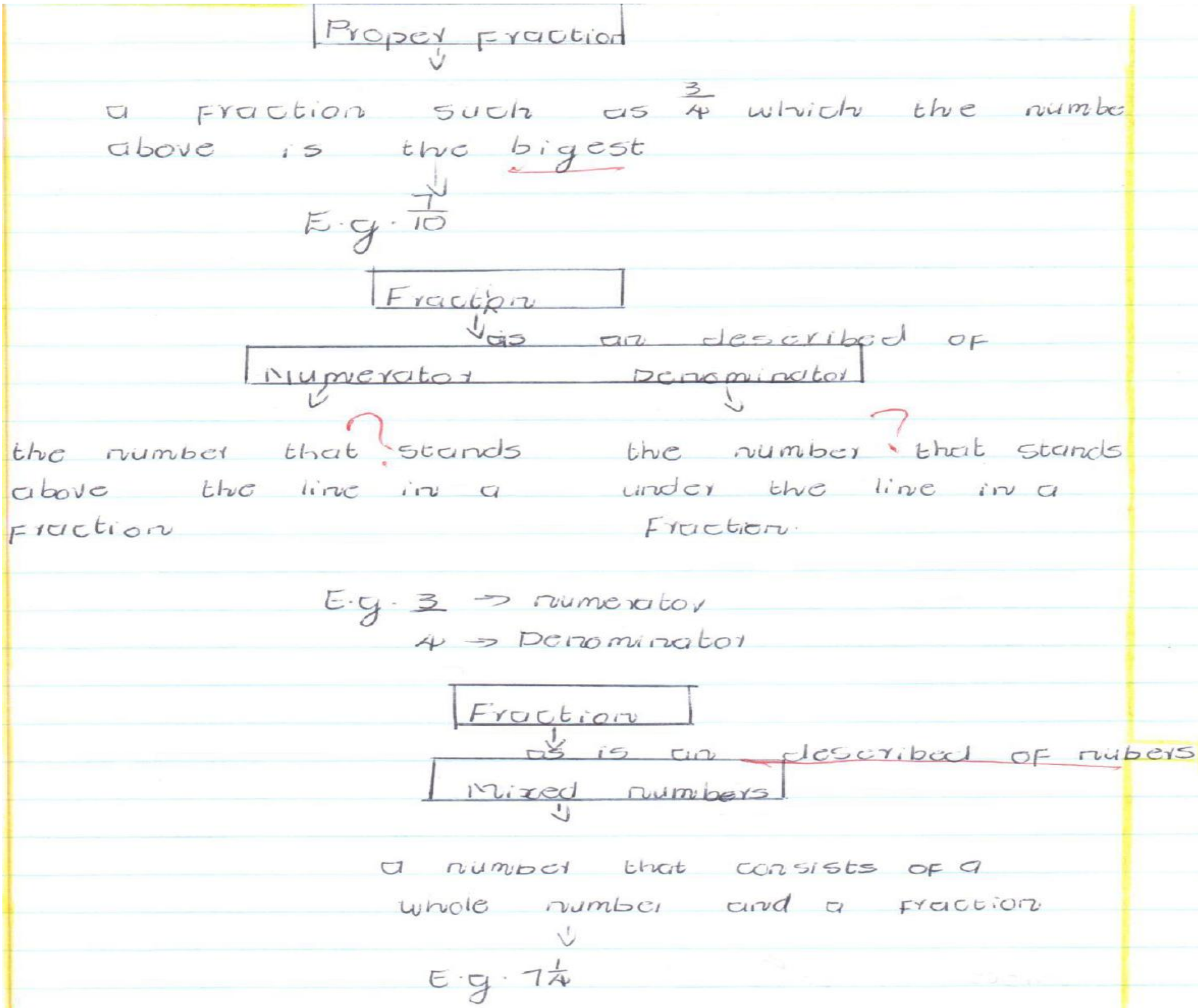


Figure 3: Learner 7's pre-intervention concept map

The second set of data was closely looked into with a view of checking if the same learner registered any progress. In this second set of data, the concept map of Learner 7 showed some improvements on inserting linking words. The following linking words could be identified from the learner's second concept map; 'is, e.g., can be, show'. This showed that the learner improved from 0 to 4 linking words. The learner sometimes repeated 'can be' in the boxes which in her mind indicate a proposition formed. A proposition is a statement about an object or event either naturally occurring or constructed which consists of two or more concepts connected by linking words (Novak & Canas, 2008).

Post intervention findings revealed that no learner drew a concept map without linking words. As a result the category of concept maps with no linking words did not exist any further. Learner 2 had two linking words in her concept map which were ‘is’ and ‘have’. Most commonly used linking words were; can be, is, for example (e.g.). Other forms of linking words used were have, has are, shows. There was an improvement on the number of linking words. The next section focuses on the issue of concept maps with fewer linking words.

Concept maps with fewer linking words

By fewer linking words I mean that there are instances where the learners had a combination of no linking words and some linking words. The nature of the links varies. Types of linking words are direct, indirect and crossed links. Direct links are links between two concepts in a single step. They express a relationship between a concept and its elements. They also become linear. Direct links are identified by the use of words like has, have etc. Indirect links represent relationships between concepts placed in a branch or in a path of the map. They use words such as ‘can have’. Cross links are links between concepts belonging to different parts or sub-maps in a general concept map. They give a map a more complex structure because they break the linearity of the relationship. They connect more than one concept. Two learners (learner 5 and learner 8) showed both no linking words and few linking words. Learner 5’s excerpt during pre-intervention is shown in figure 4 hereunder.

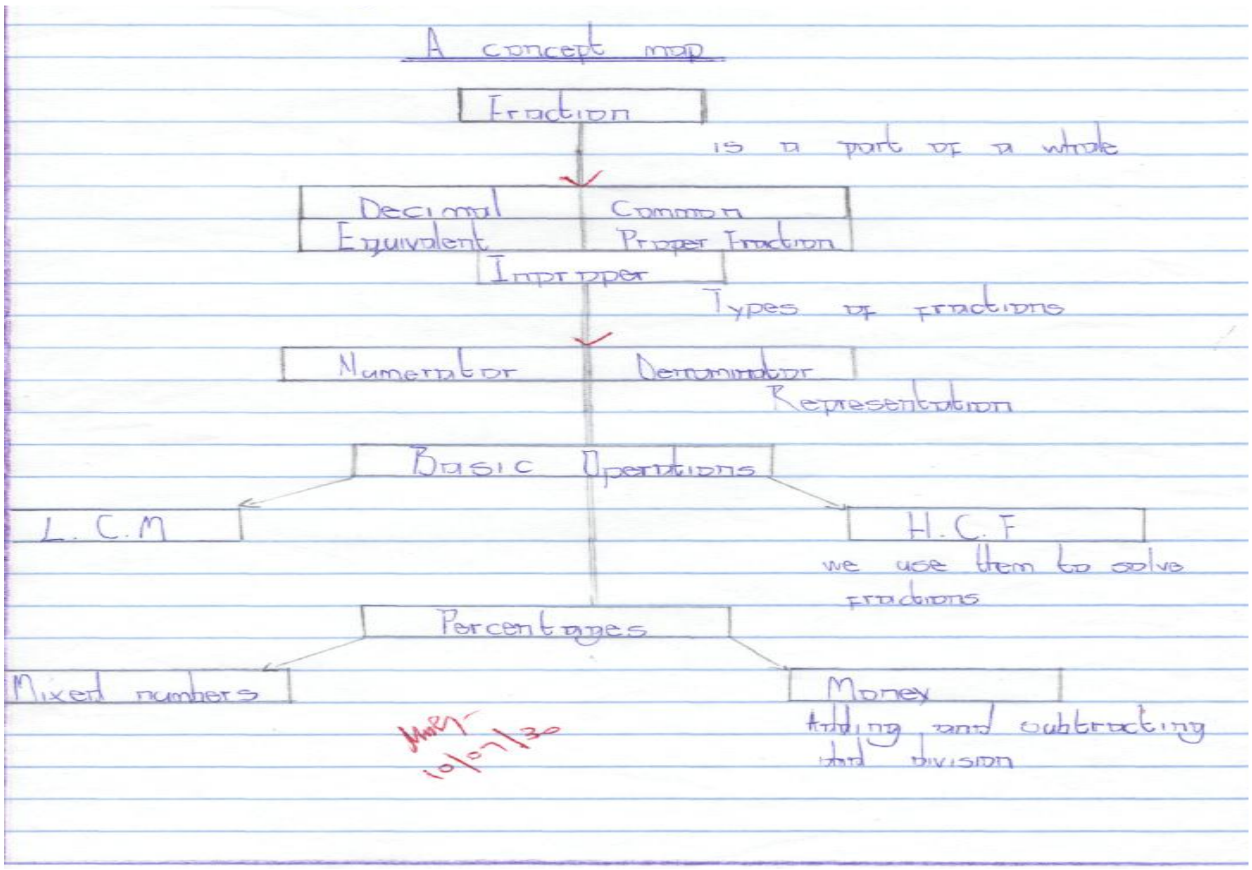


Figure 4: Learner 5 pre-intervention concept map

Let us look at how the learner uses the linking words ‘is a part of a whole’ in the map. First we see that the words come between the two concepts fraction and decimal and common after the word fraction and to him this is a linking word which relates to fraction to ‘decimal and common fraction’. Again, ‘a type of fractions’ is written below proper fraction. The question now is what meaning do the two linking words bring? In other words do the two linking words serve the intended purpose? Meaning would exist if types of fractions were written above decimal and common fractions. Though the learner showed some linking words, the meaning of the connection is not yet clear because the linking words are not connected to concepts. The linking words are separate entities from the map. The same pattern continues with other concepts like representation, which comes between the concepts numerator, denominator and basic operations. The learner might have wanted to say fraction can be represented as numerator and denominator. From the concept basic operations, there are the concepts

L.C.M. and H.C.F. without linking words which connect them. Below the concept H.C.F., the learner wrote; we use them to solve fractions as his linking word. No meaning can be detected from these relationships. He could have said we use the H.C.F. to simplify fractions. All linking words are misplaced and thus do not serve their purpose of showing the relationship between concepts. Therefore the linking words in this map did not serve their purpose of showing interconnectedness between concepts. However, the learner made a shift of placing the linking words correctly in the second set of data. Once again it is found that according to the learner, measurement can be capacity and quantity. He could have said capacity is an example of quantity and then continue to say its units are ml, litres. All his linking words are connected to the concepts regardless of relevancy or correctness. The number of linking words used increased from 4 to 6. Forms of linking words used are: use, can and consists of which are indirect and descriptive in nature. Even if these learners could not use linking words properly, 2 of the remaining learners made an attempt on correct usage of the linking words. For example, learner 9 wrote propositions like fraction can be described as part of whole and further shows how it can be represented. The relationship between the concepts gives sense.

Findings on the same issue after intervention indicated that linking words were properly placed and showed meaning. Learner 3 post- intervention concept map is shown to indicate the improvement on the position of linking words and how they connect the concepts.

Propositions made for the description of the type of angles (obtuse, acute, right, straight etc.) make meaning. The learner did not link revolution and reflex angles with types of angles. Here the learner appeared to have two concept maps as he did not link the concept quadrilaterals to other concepts. The concept quadrilateral looks like a new general term with its concepts. The descriptions are emphasized by illustrations of the different shapes like triangle and square. Linking words shown are; is, are, e.g., the, there are. Improvement on fewer linking words could be noticed.

In the above discussion I focused on the issue of concept maps with few linking words. In the next section I examined concept maps with adequate number of linking words.

Concept Maps with adequate number of linking words

In this study by adequate I refer to a significant number of linking words. In this case I do not put emphasis on the number, but that each box has a link. From the ten learners I found that 2 wrote a considerable number of concepts with linking words. With regard to this issue I used the concept map of Learner 1.

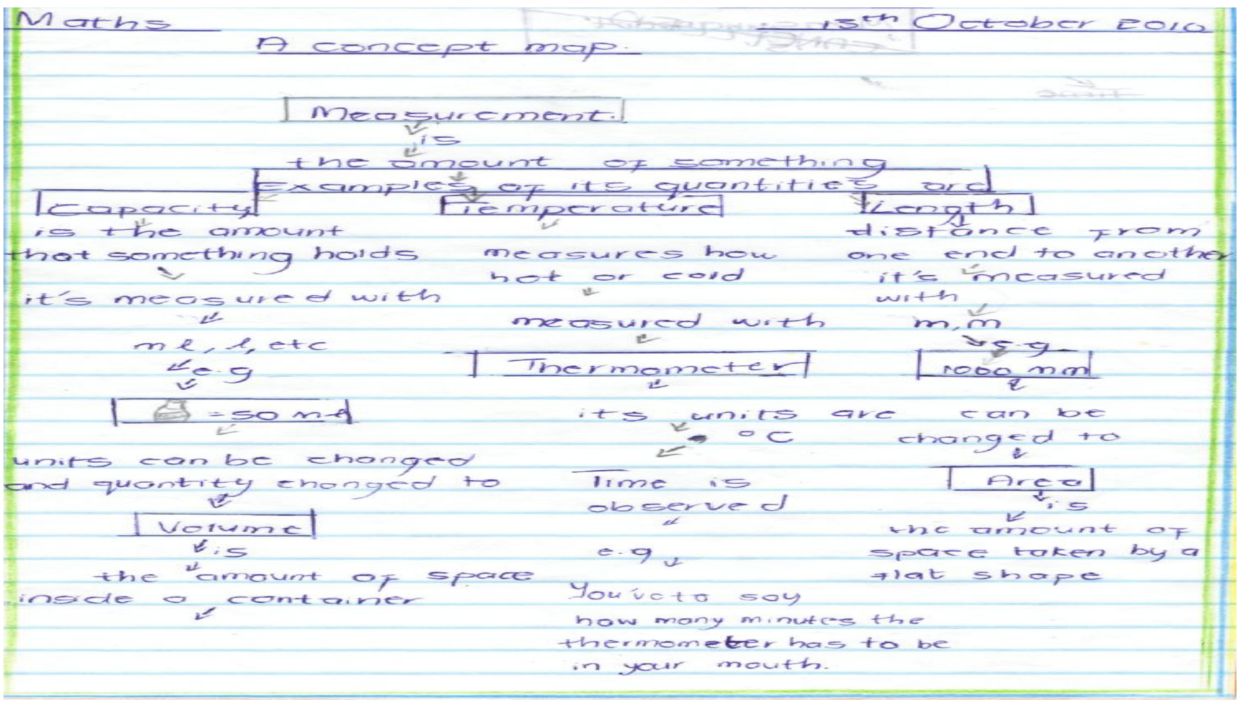


Figure 5: Learner 1 pre-intervention concept map

The learner used sentences which contained linking words to show relationship between concepts. The linking word, the amount of something is linked to examples of its quantities. Though the learner placed the linking word correctly, there is no sound relationship between the amount of something and examples of its quantities. The learner should have referred to the concepts capacity, temperature and length as types of quantities. Below these types of quantities are their definitions. Linking words used are; is and measures. Here descriptions such as temperature measures how hot or cold make meaning. We see in some instances the learner made illustrations as in 50ml bottle. The questions arise where the learner states that 1000 ml can be changed to area. Does the learner confuse area with perimeter? We can only change one kind of units to the other, e.g., we can convert mm to cm or m etc. The learner forgot that area is measured in square units. The definition of area is well phrased. Linking words that were used are: is, are, the, measures, e.g. and can be. She had both direct and indirect links which amounted to 12 in number as he repeated other forms of linking words.

No cross links were evident from the responses. Only direct and indirect links were used by the learners. They frequently used linking words such as; can be described as, is, are which are descriptive in nature. The quality of the linking words differed. There were links whose meanings were explicit while other links did not convey any meaning. In post-intervention learner 4's concept map shows a considerable number of linking words as defined earlier on. Only one box did not have a link. This is shown on the following concept map.

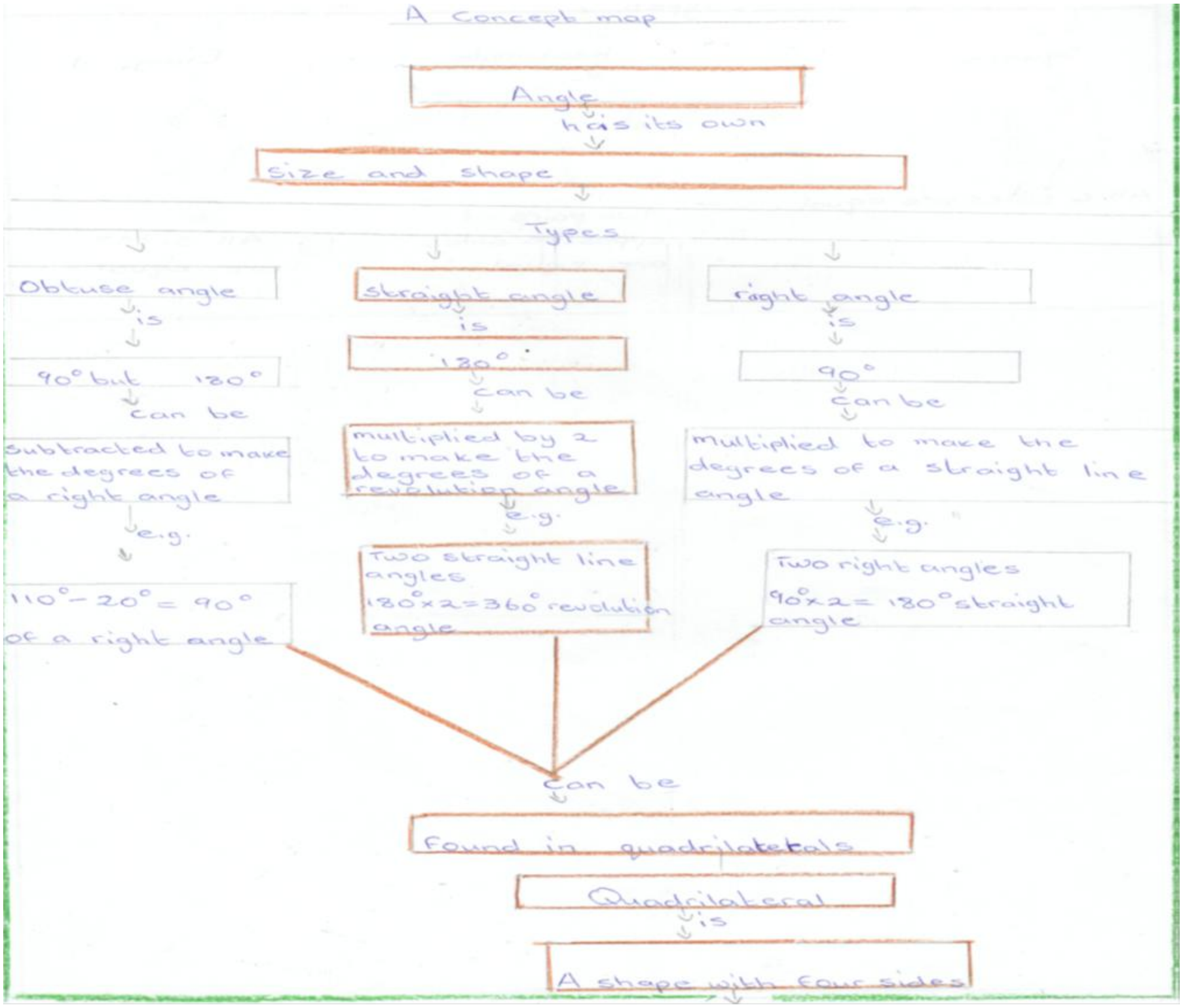


Figure 6: learner 4 post- intervention concept map

Adequate number of linking words is reflected in the above discussion. The next issue identified is the structure of concept maps.

Structure of concept maps

Concept maps are hierarchical structures which show relationship between concepts. They have the general term at the top of the structure and the specific concepts under. Words are usually enclosed in the boxes. Linking lines indicate concepts that are related. Two kinds of concept map structures are linear and circular. Linear structure moves from one concept to the next in the form of a line. Circular structure is round in shape. The shape of the boxes corresponds with the general structure of the concept map. The structure incorporates the nature of the links. Here findings revealed that most learners used linear model. 7 out of 10 learners wrote the general term ‘fractions’ at the top and the specific terms followed. One of the remaining learners drew a concept map that resembles a mind map. However, Learner 2 and Learner 10 drew concept maps which contained branches. To show this point the concept map of Learner 2 was reviewed.

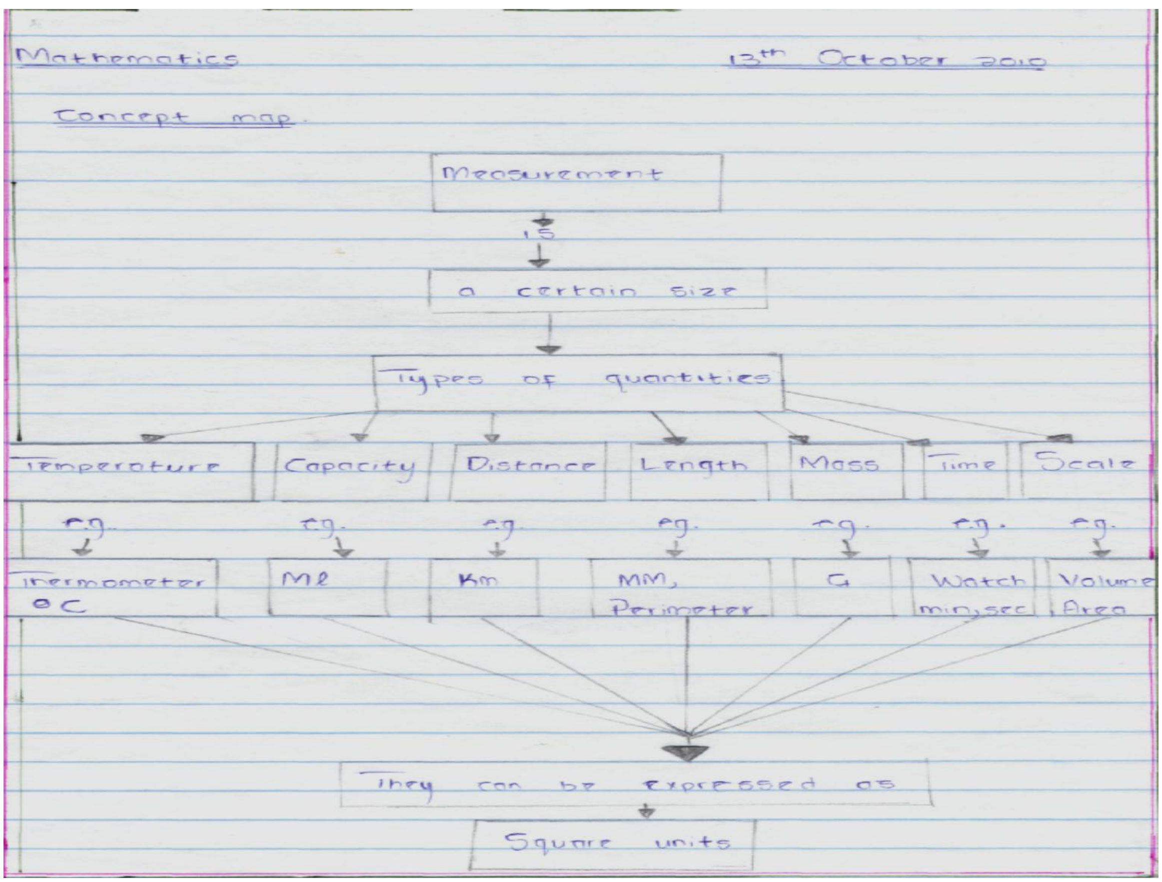


Figure 7: Learner 2 pre-intervention

The learner showed some idea of the types of quantities but could not explain them. Instead of indicating what she meant by quantities, she gave examples of which some of them were mistaken. In some instances she referred to the instruments and units as examples of instruments like watch, min, sec., are indicated as examples of time. The learner could not draw a clear demarcation between units and instruments. Furthermore according to him, scale is related to volume and area which collectively with other units, can be expressed as square units. This is not correct. He continues to show that types of quantities are related to a certain size. The two concepts are not connected by any linking word. Types of quantities should be connected by the linking word are. The branch makes sense. Square units are units for calculating area. Here we see the learner placing the concept square units as the central concept where units and instruments are connected to it. Volume is a quantity that refers to the amount of space in an object. This learner could not show the correct relationship between these concepts.

Only two concepts of the learner's concept map could not be included in the boxes. Exclusion of these concepts raised some questions like; Are the concepts denominator and numerator examples of Lowest Common Multiple? Are they general terms or specific terms? The learner could not relate the two concepts with the concept just above them. The same results concerning the structure are realized in the second set of data. Most learners drew linear concept maps with words included in the boxes. Post-intervention results showed that all concept maps were linear with the general concept at the top of the structure and specific concepts below. Every concept was inserted in the box and each box had a link. Out of the ten learners, 9 wrote the concept angle as the general term and 1 had Quadrilaterals as the general concept. The concept map of learner 4 who wrote the concept angle as the general is studied as an example.

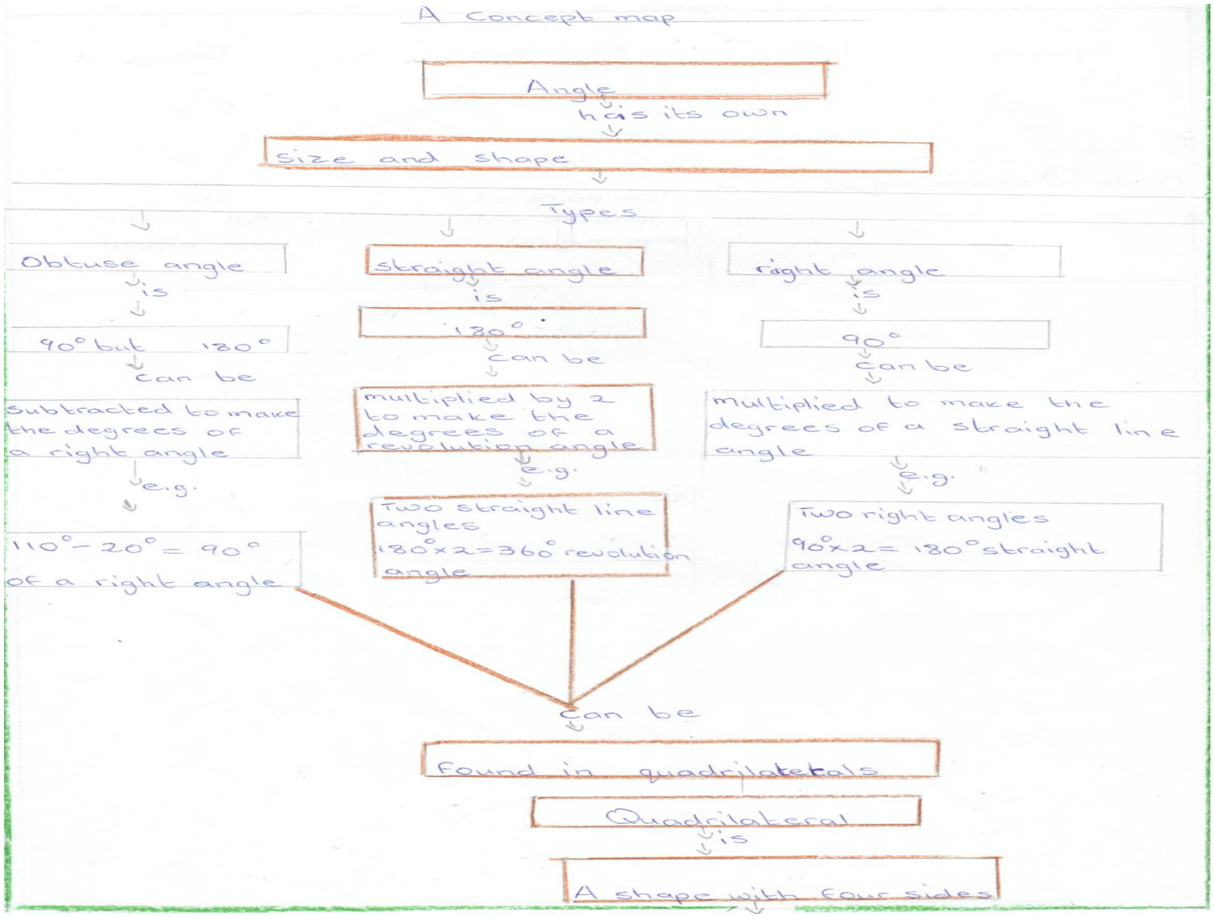
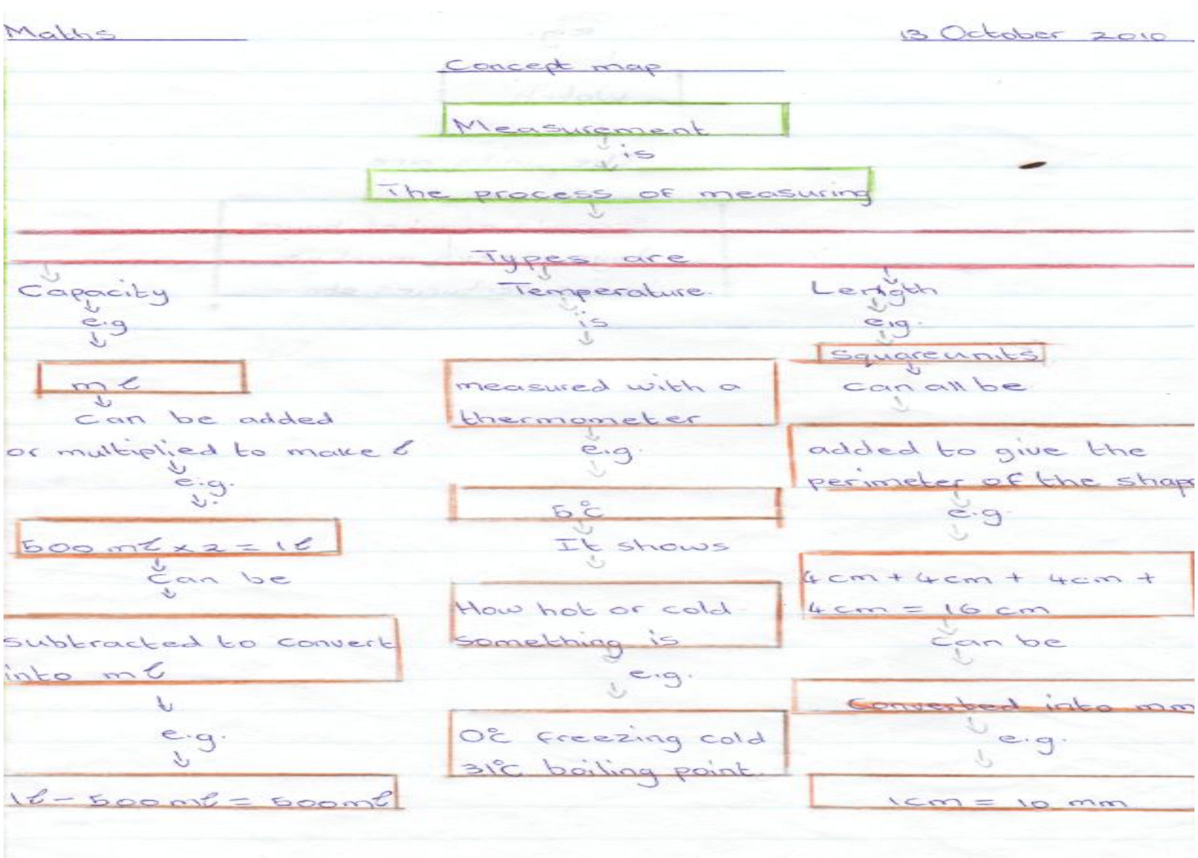


Figure 8: Learner 4 post-intervention concept map

Most learners preferred to define or describe the general concept. In contrast, the learner here gave what I may call 'properties' of angles rather than defining or describing the concept. Different levels on the concept map could be noticed each with its own elements. Level 1 reflects some of the types of angles, level 2 shows sizes of the angles mentioned in level 1, level 3 states basic operations while in level 4 the learner shows some calculations. She also expresses one angle in terms of another angle e.g., 90º x 2 = 180º which is a straight angle. The learner then connects the fourth level with quadrilaterals. She gave the correct definition of a quadrilateral. Furthermore the learner had levels which are types of quadrilaterals, their structure and she stated properties of the given structure. The other learners also had examples of structures and some properties to show emphasis. Generally, post-intervention results indicated that the learners' concept maps conformed to the requirements of a concept map. In the section that follows I discuss findings of the third issue namely; the number of concepts used from the given list.

In concept mapping, concepts relating to a particular topic are provided. Usually the number of concepts in the list ranges from about 15 to 25 concepts. The number of concepts for the first concept map was 15, 16 for the second concept map and 20 for the third concept map. It is the choice of the learner either to stick to the list provided or add new concepts that would still be relevant to the main topic. There were learners who used only words provided in the list while on the other hand there were those who added their new concepts. Pre-intervention analysis showed that 9 learners out of 10 used only concepts given in the list. This suggests that most learners seem to depend on the list provided and as a result do not have confidence of what they know. 1 learner out of 10 learners had 1 additional concept i.e. freezing point. The second concept map of Learner 4 displayed this as shown on the map below:



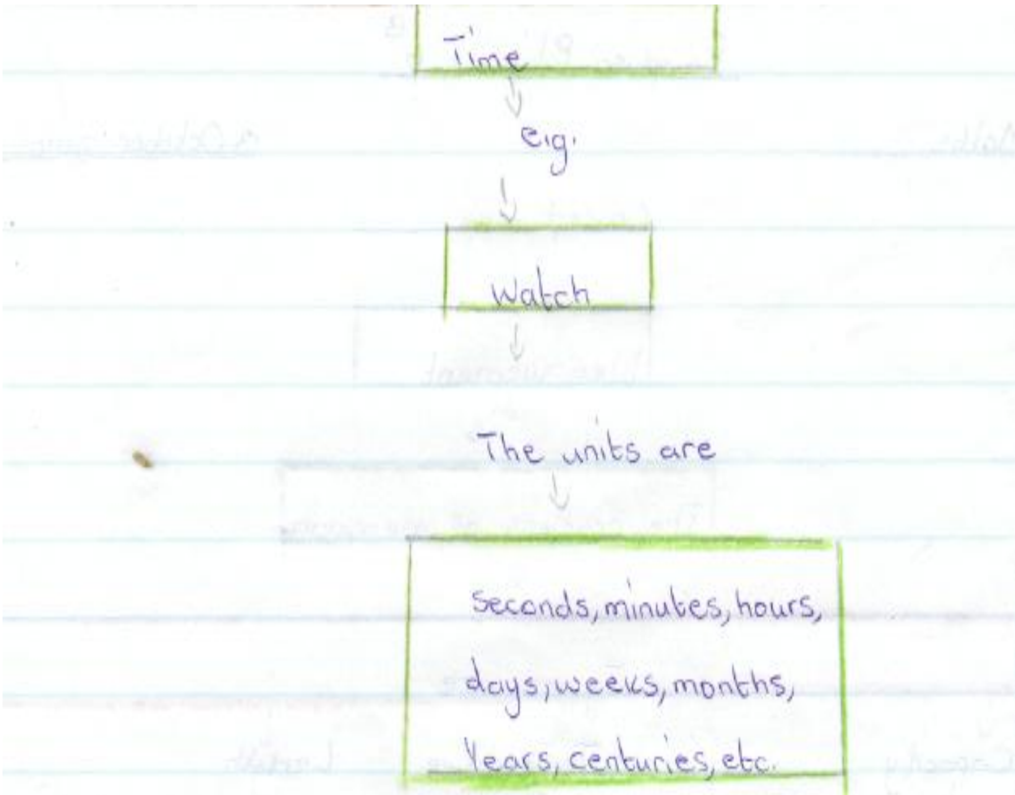


Figure 9: Learner 4 pre-intervention concept map

The number of concepts used by Learner 4 is 15 out 16 in the second stage while in the first stage she used 25 concepts. Post-intervention showed that the number of concepts used from the word bank for the same learner (learner 4) was 14 out of 20. Results showed that 4 learners used 14 concepts; another 4 learners used 13 concepts while the remaining two learners; one used 18 and the other 20 concepts. The concepts were properly used and the flow of ideas conveyed meaning. Though learners used lesser number of concepts than in the second session of pre-intervention stage, the quality of the usage of the concepts seemed to be better in post-intervention stage. The number of concepts used for drawing concept maps has been addressed above. Realizing that representation of learners alone cannot provide enough evidence of their thinking, I included interviews to get more information on learners' understanding.

Interviews on learners' concept maps

I conducted interviews after learners had drawn their second concept maps on measurement. The excerpt of Learner 3 on interviews was analysed.

L3
T: What should concept maps have?
L: Boxes, lines, arrows.
T: Which other things you should always think about when you draw a concept map?
L: Describe words.
T: What are linking words?
L: They are describing words like "is".
T: What do you understand by the general term?
L: It is a bigger word which we write at the top and we write specific words under.
T: Why do arrows have to be shown on a concept map?
L: Because they show us the words which are related.
T: What is ml?
L: We use them to measure capacity.
T: What do we call this ml?
L: Units for measuring capacity.
T: You linked thermometer to temperature. What is thermometer?
L: It is the object used to measure temperature.
T: What are square units related to?
L: Measurement of a shape.
T: Do you find concept maps useful?
L: Yes because they help me to think a lot and revision for exam.

The learner defines measurement as the process of measuring on his concept map. He further indicates types of measurement as capacity, length, time and temperature. Furthermore, ml is written as example of capacity but when interviewed, the learner could clarify it as the units for measuring capacity. The same applies to length, time and temperature. He could tell that thermometer is an instrument for measuring capacity while on the map he shows that ºC is measured with thermometer. On the map the learner shows that ml can be converted to dm. What the learner knows is that the concept ml can be changed to another form of units but is not sure to which ones. To him any units can be converted irrespective of the type of quantity. Thermometer is linked to ºC on the map but it is not explained how they are related as there is no linking word that connects them. Verbally he said that thermometer is the object for measuring temperature. On the map the learner shows that the units, sec, min and hours can be measured by square units. When asked what are square units connected to? He replied that square units are related to the measurement of a shape. The learner has an idea that square units are related to a shape but does not know under which condition are the square units used. The next excerpt shows how Learner 1 clarified her concept map through interviews.

L1

T: What should concept maps have?
L: It must have boxes, general term, linking words and arrows.
T: Which other things you should always think about when you draw a concept map?
L: The general term
T: What do you understand by the general term?
L: It is a word which we write on top.
T: Why do arrows have to be shown on a concept map?
L: They show us the words which go together.
T: What are linking words?
L: The linking words join words.
T: Are temperature, capacity and length examples of quantities?
L: No, they are types of quantities we can measure.
T: How can we change millimetres to area?
L: No teacher (shaking her head) we cannot change millimetres to area because area is the amount of space taken by a shape and millimetres is the units of length.
T: Is it possible to have only words or concepts that are given in the word bank?
L: No, you can have your own words which do not appear on the list.
T: Which quantity shows how heavy an object is?
L: It is mass.
T: Which units are used to measure mass?
L: Kilograms.
T: Do you find concept maps useful?
L: Yes, because concept maps help us in revision and we can learn more.

The learner begins with the definition of measurement as the amount of 'something'. The definition is not clear as the concept 'something' can mean anything according to the learner. When expanding on what the learner refers to as examples of quantities, it is evident that the learner confuses types of quantities as examples of quantities but is able to define the different quantities. In interviews, Learner 1 shows that millimetres cannot be changed to area because the first refers to the units while the latter means the space covered by a shape. The learner again could not identify volume and area as quantities but was as well able to define the concepts. This misunderstanding is what Leauby and Maas (2005) refer to as misconceptions. This may suggest that the concepts learned previously were learned through rote learning or superficially Boo and Hoh (2001). This again suggests that, as Scagnelli (2002) claims, knowledge was not internalized and therefore could not be transferred between topics or across subjects.

However, Learner 1 could give and link appropriate units for the concepts capacity, temperature and length. In interviews, the learner clarified the concepts temperature, capacity and length as types of quantities we measure. The learner on the concept map expanded on the concept time in relation to thermometer. Learner 1 knows that time is observed when using thermometer in other fields though not mentioned but gives an example of a context where time is observed, like when a human temperature is measured by putting a thermometer in a person's mouth. This is usually practiced in health education. Here the implication is that the learner could relate the concept relevantly to another context even if it was during a mathematics lesson. Up to this stage of the report, the focus has been on the first research question which was; what kind of connections do learners make? In the next section I looked at the performance of the learners with the aim of responding to the second question.

What came out of the analysis of learners' Concept Maps as they moved from Concept Map without linking words to those with few or comprehensive linking words can be described as follows:

Findings on the second research question

The second research question was; is the nature of concept maps learners produce reflective of their performance? I used mark schedules of four terms to cover both pre-intervention and post –intervention phases to confirm performance. Though I did not confine myself to the statistical analysis of learners' performance, I only showed marks of learners who had no linking words and learners who had adequate links as reflected in the table below:

	Learners with no linking words		Learners with adequate links	
	L2	L3	L1	L4
Term 1	60	66	45	77
Term 2	52	44	51	79
Term 3	72	55	30	75
Term 4	67	64	58	88

Table 1: Learners' performance in % for 2010

Looking at the table it is evident that the nature of a concept map the learner draws does not always match with his/her performance. There are instances where the learner who had no linking words generally performed better like learner 2 while on the other hand the learner who had most meaningful links did not perform well as the case with learner 1. Lack of linking words might emanate from poor relevant mathematics vocabulary at hand during concept map drawing task. However, learner 4 had most meaningful links and could also perform well. On the basis of these findings I therefore conclude that the nature of the concept maps learners draw is not always reflective of their performance. What I found interesting was that generally the use of concept maps during post-intervention improved the performance of the learners.

Nature of linking words from non- to adequate number of linking words.

Generally learners began with Concept Maps with no linking words and moved to Concept Maps with simple, common linking words which one would call descriptors e.g., ‘can be’ is, and further moved to more complex ones e.g., measures. Thus the nature of linking words was developmental.

Conclusion

The purpose of this study was firstly to reflect on the usage of concept maps to enhance meaningful teaching and learning of mathematics and secondly, to see if the nature of concept maps is reflective of learners’ performance. Looking at the issues that emerged on learners’ concept maps, I conclude that: on linking words, even if there were some concept maps whose concepts were not properly linked learners could to a greater extend, connect mathematics concepts. Concepts were no longer viewed as isolated entities but as interconnected mathematics concepts. This is supported Grevholm (2008) when he asserts that conceptual knowledge is knowledge that is rich in relationships. This indicates that conceptual change took place. Learners also improved on the position, relevance and number of linking words. However, cross links were visually not available. Concept maps were useful in this research. Interviews as well made it possible to reach learners’ thinking.

Post-intervention marks indicated the impact of concept maps on the learners' performance. Concept maps proved that the nature of concept maps learners produce is sometimes reflective of their performance.

The next chapter is on reflections, conclusion and recommendations.

CHAPTER FIVE: REFLECTIONS, CONCLUSION AND RECCOMMENDATIONS

Overview

In the previous section I focused on analysis of data and the results thereof. In this chapter I gave summary of the research findings. Reflections, conclusion and recommendations were also reflected. I categorized recommendations as recommendations for classroom practices, recommendations for teacher education and recommendations for further research.

The purpose of this study was firstly, to reflect on the usage of concept maps for meaningful teaching and learning of mathematics and secondly, to find if the types of connections learners make are reflective of their performance. The research questions that the study intended to answer were: what kinds of interconnections learners make? It is therefore important that learners make links with meaning i.e., they should connect concepts more meaningfully. The second question was: Is the nature of a concept map learners produce, reflective of their performance? Concept mapping is a strategy that affords learners the opportunity to make these relationships. Learners stand a good chance of performing well if they can make quality relationships. Here follows discussions on issues identified during analysis.

Concept maps with no linking words

From the analysis only 2 learners out of 10 did not have any linking words. This does not mean that the concepts supplied were new to the learners as they were also prescribed in previous grade. The implication may be that the concepts were learnt superficially or through memorization because any knowledge acquired through traditional method is not retained. Lack of linking words may as well suggest that learners had only procedural understanding.

Concept maps with fewer linking words

Looking at the excerpt of Learner 5's pre-intervention concept map, it is realized that the learner did not link the definition of a fraction to the general concept of fraction. The proposition 'is part of a fraction' is in isolation. It would make meaning if it was properly placed. The implication might be that the learner was not confident with how and where to write the linking words. The types of fractions as the linking phrase is misplaced as well, but Learner 5 could give correct types of fractions. His knowledge and understanding of the types of fractions was not convincing. This is seen as the learner did not give any example of either of the given types. His concept map could not reflect meaningful learning and this suggests that the connections made by the learner were trivial despite the explanation given prior to concept map drawing activity. This may suggest that the learner had linking words in mind but could not express himself. In line with this speculation researchers like Cobb, Yackel and Wood (1992) revealed that the difficulty that learners have with mathematics is largely linguistic and not conceptual. Proper language in mathematics should be emphasized. Mathematics concepts should be taught using mathematics language. To support this idea Ernest (1991) argues that the basis of mathematical knowledge is linguistic knowledge, connections and rules. However the learner displayed his 'own' understanding of the concept. To the teacher the concept was useful in that it identified the gaps of the learner. Post intervention concept map of Learner 5 showed improvement in correct positioning of linking words, direction of connection and provision of examples. Novak and Canas (2008) argue that examples in a concept map help to clarify the meaning of a given concept. The learner went to the extent of giving illustrations to clarify his connections. Usikin (1996) in Mwakapenda (2004) supports this idea by stating that 'mathematics is a written, spoken and symbolic or pictorial language. Repeated use of concept map gradually widened the learner's mind. Interviews showed that

Structure of concept maps

Concerning the structure of the concept maps, learners began confusing concept maps with mind maps. Post intervention results showed that there was a marked change on concept map drawing e.g., learner 4 post intervention excerpt shows a hierarchical structure which is one of the requirements of a good concept map. Logical propositions could also be noticed and this was indicative of improved performance on mathematics content. Learners were able to connect concepts in a hierarchical order i.e., concepts were connected from general to specific.

Interviews were of great value as they clarified what learners had on paper. Learner 3's interview excerpt showed that he could not relate square units to measurement of the area which to him were separate. Through concept mapping, learners' misconceptions could be identified. Therefore concept maps proved to be useful in this research.

Traditional teaching as Haapala et al. (2002) argue does not provide an adequate forum for a diversity of learners to demonstrate their skills profile and the breadth of learning. The classroom is a multi-dimensional environment. This implies that students learn in different ways and therefore different approaches must be used to help students learn (Maas & Leauby, 2005). Concept mapping is one such approach.

Conclusion

Gradual increase in the number of links and meaningful propositions learners made was a positive indication that concept maps provided meaningful teaching and learning. Concept mapping tasks and interviews made it possible for both the teacher and the learners to see their flaws. Even if the research showed that concept maps were able to explore meaningful teaching and learning for grade 6 mathematics learners, there are some negative impacts that concept maps have. Concept maps are time consuming. Sometimes the space available for the learner to express him/herself through propositions is not enough and thus learners end up not writing other linking words. Concept maps alone cannot make teaching and learning successful, they should still be used with other strategies like the telling method when explanation of concepts is necessary. Concept maps are inherently selective. They display partial knowledge of an individuals' mind.

Despite the disadvantages that concept maps have, in this report the research questions were answered.

Recommendations on how to facilitate learners' use of Concept Maps

The lesson on the use of Concept Maps needs to be clearly planned. As teachers we must appreciate to see learners moving from no linking words to fewer linking words. The idea is not to put much emphasis on the number of linking words but on the quality of linking words and sense they make. We should also exercise patience as the impact of using Concept Maps is not immediate. My advice to teachers is to see on how we take these learners forward or to the next level of linking words.

Recommendations for classroom practices

Concept mapping can be introduced in early mathematics classes as Haapala et al. (2002) declares that concept mapping is a highly flexible tool that can be adapted for use almost any group of learners in education, students and teachers from primary school to universities. Introduction of this strategy in early years of schooling will provide learners with opportunities to display relationships among concepts in a topic, between topics and between domains of mathematics like algebra and geometry.

Educators should reduce or eliminate the use of lecture method as it is boring, mind numbing for learners and monotonous for teachers (Lujan and Dicarlo, 2006). Active involvement improves learners' conceptualization of systems and increases their level of retention. Educators should therefore act as 'mediators' (Gonzalez et al. (2008). The importance of writing meaningful propositions should be emphasized because it is through meaningful propositions that meaningful learning takes place. Educators are advised to explain mathematics concepts using correct mathematics language. Once the concepts are well understood, it becomes relatively easy for them to connect the concepts. During interviews learners generally showed positive attitude towards concept mapping. This indicates that learners can have fun when working with mathematics.

Recommendations for teacher education

Most educators are not familiar with concept mapping. As a result there is high possibility that mathematics educators may demand workshops and in-service training on concept mapping. Therefore recommendations are given for teacher education that could take the form of educator developmental workshops either at school, cluster or district level. Curriculum designers may include concept mapping as a new and intervention strategy in their planning. Content coverage is a challenge to most educators as they rush for covering prescribed curriculum content at the expense of meaning-making on the part of learners. Curriculum-centric teaching as Reinagel (2010) advocates puts emphasis on what learners ‘ought’ to know whereas in contrast, learner-centric teaching focuses on what students actually ‘need’ to know and will find personally meaningful. Reinagel (2010) continue to point out the following limitations of curriculum-centric teaching:

- Curriculums are developed by people who teach or taught based on their own impressions of what learners will find useful rather than developed directly based on feedback and inquiries from students.
- It is fairly inflexible. It focuses on specific lessons that must be taught in a specific order. There is little room for day-to-day flexibility on the scheduled content and as such the curriculum does not respond to the needs of todays’ learners.
- It is uniformly taught to a broad range of students, whose varying levels of foundational knowledge and learning styles serves to negate the effectiveness of what is taught. This implies that it does not cater for individual learners.

It is unfortunate that our education system is trapped in these limitations. Currently there are work schedules and pacesetters which dictate to educators what to teach and when regardless of the time available to the educator and the type of material learners the educator is faced with. Teaching should be viewed as a relational experience rather than merely ‘academic’. Therefore anything that is taught should be relevant to the learners’ lives, comprehensible by learners and taught in a manner that ensures learners are able to connect with the way it is being taught. The knowledge needs to be cultivated, manipulated and organized into meaningful learning.

Based on this concern I therefore recommend that curriculum designers should cut down the content. Learners must have time to explore underlying concepts and generate connections which can be transferred to other topics at different levels.

Recommendations for further research

Most researches were done on concept mapping as evaluation tool. Further research on concept mapping for meaningful teaching and learning is still much wanting especially that the strategy is in its infancy in terms of its application in South African primary schools. Multiple connections of concepts and cross links should be encouraged and be taught during induction sessions.

REFERENCES

Afamasaga Fuata'i, K. (2004). *Concept maps and vee diagrams as tools for learning near mathematics topics.*

Afamasaga-Fuata'I, K. (2011). *Students' Attitudes and Problem Solving with Vee Diagrams*. The Assessment Handbook, Vol 5(1). PEMEA

Afamasaga–Fuata'I. (2007). Communicating Students'Understanding of Undergraduate Mathematics using Concept Maps*. Proceedings of the 30th Annual Conference of the Mathematics Education Research Group of Australia.* Merga Inc. Watson, J & Beswick K. (Eds).

Angen, M.J. (2000). *Evaluating Interpretive Inquiry Reviewing the validity debate and opening the dialogue*. Qualitative Health Research.

Australian Association of Teachers of Mathematics (AAMT). (2006). Standard of excellence in teaching Mathematics in Australian Schools. Sydney, Australia: AAMT>

Ausubel,D.,Novak, J.& Hanesian,H.(1978). *Educational Psychology*: A cognitive View. Holt , Rinehart and Wintson, New York.

Ausubel, D.P. (1963). *The Psychology of Meaningful Verbal Learning.* New York, NY: Gune and Stratton.

Ausubel, D.P. (2000). *The acquisition and retention of knowledge*: A cognitive view. Dordrencht, Boston: Kluwer Academic Publishers.

Baralos, G. (2002). *Concept Mapping as Evaluation Tool in Mathematics.* Centre for Educational Research, Greece.

Bassey, M, (1999). *Case study Research in Educational settings*. Sikes, (Ed). Open University Press United Kingdom.

Boo, H.K & Hong, Y.K. (date unknown). *Using Concept Maps to Enhance Meaningful Chemistry Learning.* National Institute of Education, Nanyang Technological University, Singapore.

Canas, A.J. & Reiska, P. (2008). Concept mapping in Teaching and Learning Process of Rate of Change*.Proceedings of the Third International Conference on Concept Mapping.*

Cobb, P., Yackel, E. & Wood, T. (1992). A Constructivist Alternative to the Representational View of Mind in Mathematics Education. *Journal for Research in Mathematics Education,Vol.23, N01 pp. 2-33* Stable URL.

Creswell, J.W. (2007). *Qualitative Inquiry and Research Design, Choosing among five approaches.* University of Nebraska, Lincoln SAGE Publications.

Creswell, J.W. (2008). *Educational Research*: Planning, conducting and evaluating qualitative and qualitative research (2nd Ed). Upper Saddle River, N.J: Merril/Prenctice Hall.

Creswell, J. W. (2009). Research design: *Qualitative, quantitative and mixed methods approaches* (3rded.) thousand Oaks, CA: Sage.

Department of Basic Education (2010). Pretoria

DOE (2002*). Assessment Guidelines for Mathematics Intermediate & Senior Phase*.

Dreyer, M.M. (2008). *Concept Maps as a learning strategy for acquiring Business English Vocabulary.* Doctoral thesis, University of Johannesburg. Retrieved May, 14, 2012 from http://books.google.co.za/books/about

Ernest, P. (1991*). What is the Philosophy of Mathematics Education*? University of Exeter, United Kingdom

Gonzales,F.M. & Novak, J.D. (1993). *Aprendizaje Significative technicas y aplicaciones.* Serie: Education y Futuro no. 18. Madrid, Argentina: Editorial Cincels. A

Gonalez and Novak (2002). Meaningful Learning: *The Essential Factor for Conceptual Change in Limited or Inappropriate Propositional Hierarchies Leading to Empowerment of Learners*. Wiley Periodicals, Inc. Gregory J, Kelly and Richard E. Mayer, Section Editors

Grevholm, B. (2008). Concept Maps as Research tools in Mathematics Education*. Proceedings of the 3rd International Conference on Concept Mapping*. Canas, A, J. et al. (Eds). Tallinn, Estinia abd Finland.

Guinon, L.A., Diehl, D.C. &McDonald, D. (2011). Triangulation:*Establishing the Validity of Qualitative Studies*

Haapala, A. et al. (2002). *Concept Maps as a tool for Meaningful learning and assessment in an introductory statistics courses.* University of Joensuu, Finland. Retrieved March, 20, 2012 from htt://www.leeds.ac.uk/educol/documents/00002388.htm

Haiyue, J., & Yoong, K. (2010). *A network Analysis of Concept maps of Triangle Concepts*. Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia. Fremantle: MERGA.

Haseman, K. & Mansfield, H. (1995). *Concept Mapping in Research on Mathematical Knowledge Development*; Background, Methods, Findings and Conclusions, Educational Studies in Mathematics, vol. 29 pp. 45-72

Hough, S. et al. (2007). *Using concept maps to assess change in teachers' understanding of algebra*: a respectful approach. J Math Teach Edc 10:23-41.

Kinchin, I.M. (2000). *Concept Mapping in biology*. Journal of Biological Education 34 (2) pp 61-68.

Leedy, P.D. & Ormrod, J.E. (2005). *Practical Research.* 8th Edition. Pearson Educational Inc. Pearson Prentice Hall.

Lujan, H.L.; & Dicarlo. S.E. (2006*). Too much teaching not enough learning*: what is the solution? Adv. Physical Educ. 30: 17-22

Maas, J.D., & Leauby, B.A. (2005). *Concept Mapping –Exploring its value as a meaningful Learning tool in Accounting Education.* Global Perspectives on Accounting Education Vol2 pp 75-98

McGowen, & Tall, D. (1999). *Concept maps and schematic diagrams as devices for documenting the growth of Mathematical knowledge.* William Rainey Harper College. Palatine & Maths Education Research Centre, University of Warwick USA

McMillan, J.H. & Schumacher, S.(2009). *Research in Education*: Evidence-Based Inquiry.(7th Edition). My Education lab Series.

McMillan, J.H. (1996). *Educational Research – Fundamentals for the Consumer.* 2nd Edition. Collins College Publishers.

McMillan, J.H. & Schumacher, S. (2010). *Research in Education*. Jossey – Bass Publishers San Fransisco.

Merriam, S.B. (1998). *Qualitative Research and case study Applications in Education.* Jossey – Bass Publishers San Fransisco.

Moreira, M.A. (2011). *Why concepts, why meaningful learning, why collaborative activities and why concept maps?* Meaningful Learning Review V 1 (3) pp 1-11

Mwakapenda, W. (2003*). Concept mapping and context in mathematics education.* The Mathematics Education into the 21stCentury.

Mwakapenda, W. (2005). *Examining understanding in Mathematics*: A perspective from concept mapping in R Vital Researching Mathematics Education in South Africa. Perspective, Practice and Possibilities.

Mwakapenda, W. (2004). *Understanding student understanding in mathematics in Pythagoras* 60, pp. 28-35

Naidoo, S. (2006).*Using Concept mapping to explore Grade 11 Learners' Understanding of the function Concept*. University of the Witwatersrand, Johannesburg.

Nasrabadi & Yekta, P. (2004). Concept mapping as an educational strategy to Promote meaningful learning*. Journal of Medical Education Vol 5 No. 2* .Iran.

Novak, J.D., & Canas, A.J. *The Theory underlying concept maps and how to construct and use them.* Technical Report IHMC CmapTools 2006-01 Rev 01-2008. Florida Institute for Human and Machine Cognition 2008 available at : http://cmap.ihmc.us/ Publications/ Research papers / TheoryUnderlying ConceptMaps.pdf

Novak, J.D.,& Musona, D. (1991). A twelve year longitudinal study of science concept leaning. American Educational Research Journal. 28 (1), 117-153

Novak, J.D. (2003). The Promise of New Ideas and New Technology for Improving Teaching and Learning.*A Journal of Life Science Education: The American Society for Cell Biology. Vol 2 No-2 pp 122-132*.

Novak, J.D. (2010). The Universality and Ubiquitousness of Concept Maps. Concept Maps: Making Learning Meaningful. *Proc. Of the Fourth Int. Conference on Concept Mapping* Sanchez.J., Canas, A.J. & Novak, J.D. (Eds.). IHMC. USA.

Pajares, F.(2007). *The Elements of a proposal.* Emory University. Retrieved April, 11, 2012 from http: //www.des.emory.edu/mfp/proposal.html

Palys, T. (2008). *Purpose Sampling.* Given, LM (Ed.) The sage Encyclopedia of Qualitative Research Methods. Sage. Thousand Oaks.

Patton, M.Q. (2002*). Qualitative Research and Evaluation Methods*. Thousand oaks, CA: Sage publications

Pedro et al. (2000). *Concept maps in Mathematics Education.* A possible Framework for students' Assessment. Universitat de Valéncia.

Reinagel, S. (2010).*The Essential Ingredient for Meaningful Teaching*. Retrieved May, 28, 2012 from http://silasreinagel.blogspot.com/2010/

Rhee, Y. (2004). *What Is a Case Study?* The EPO chain is relationships management; a case study of a government organization. Unpublished doctoral dissertation, University of Maryland, Collage Park.

Ruiz – Primo, M.A. (2004). *Examining Concept Maps as an Assessment Tool.* Concept Maps: Theory, Methodology, Technology. Proc. of the First Int. Conference on Concept Mapping. Canas, A.J., Novak, J.D. & Gonzalez, F.M. (Eds.) Pamplona, Spain.

Scagnelli, L (2002). *Using Concept Maps to Promote Meaningful Learning* Chiron. Valdosta. Edu/arc/vol1 no 2/…/scagnelli.pdf

Schimittau, J. (2004). *Uses of Concept Mapping in Teacher Education in Mathematics.* In A.J. Canas and Gonzalez (Eds.) Concept Maps, Theory Methodology, Technology pp 571-577. Pamplona, Spain. Navarra. Novak, J.D., & Canas, A.J. (2008). The Theory underlying concept maps and how to construct and use them. Technical Report IHMC concept map tools.

Sieber, J.E. (1992). Planning Ethically Responsible Research*: A Guide for Students and Internal Review Boards.* Applied Social Research Methods Series, volume 31 Newbury Park, CA : Sage Publications.

Stake, R. (2003). *Case studies*. In N.K. Denzin & Y.S. Lincoln (Eds.), Strategies of qualitative inquiry (2ndEd.) (pp. 134-164). Thousand Oaks, CA: Sage.

Stoica, I, Moraru, S & Miron, C. (2011). *Concept Maps, A Must For The Modern Teaching - Learning Process.* Romanian Reports in Physics, Vol.63.No.2, P.567-576

Tyler, J. (2009).*What is Meaningful Teaching*? Retrieved May, 21, 2012, from http://jennty199.hubpages.com/hub/what.

Van Boxtel, C. Van der Linden, J. Roelfos, E & Erkens, G. (2002*).* Collaborative Concept Mapping: *Provoking and Supporting meaningful Discourse promoting thinking through peer learning*. Vol 41 (1) (pp. 40-46).

Wikipedia, the free Encyclopedia. *Learning* en.wikipedia.org/wiki/learning

Williams, C.G. (1995). *Concept Maps as research tools in mathematics.* A Paper Presented for Roundtable Discussion at the Annual Meeting of the American Educational Research Association pp.18-22 San Fransisco.CA.

Williams, C.G. (1998*). Using concept Maps to Assess Conceptual Knowledge of Function.* Journal of Research in Mathematics Education. Vol29 (4) pp.414-421

APPENDICES

Appendix 1: Concept mapping task on Fractions

Appendix 2: Concept mapping task on Measurement

Appendix 3: Concept mapping task on Angles

Appendix 4: Excerpts of learners' maps

Appendix 5: Interview questions

Appendix 6: Excerpts of learners' interview transcripts

Appendix 1: Learner task 1

Draw a concept map using the following concepts.

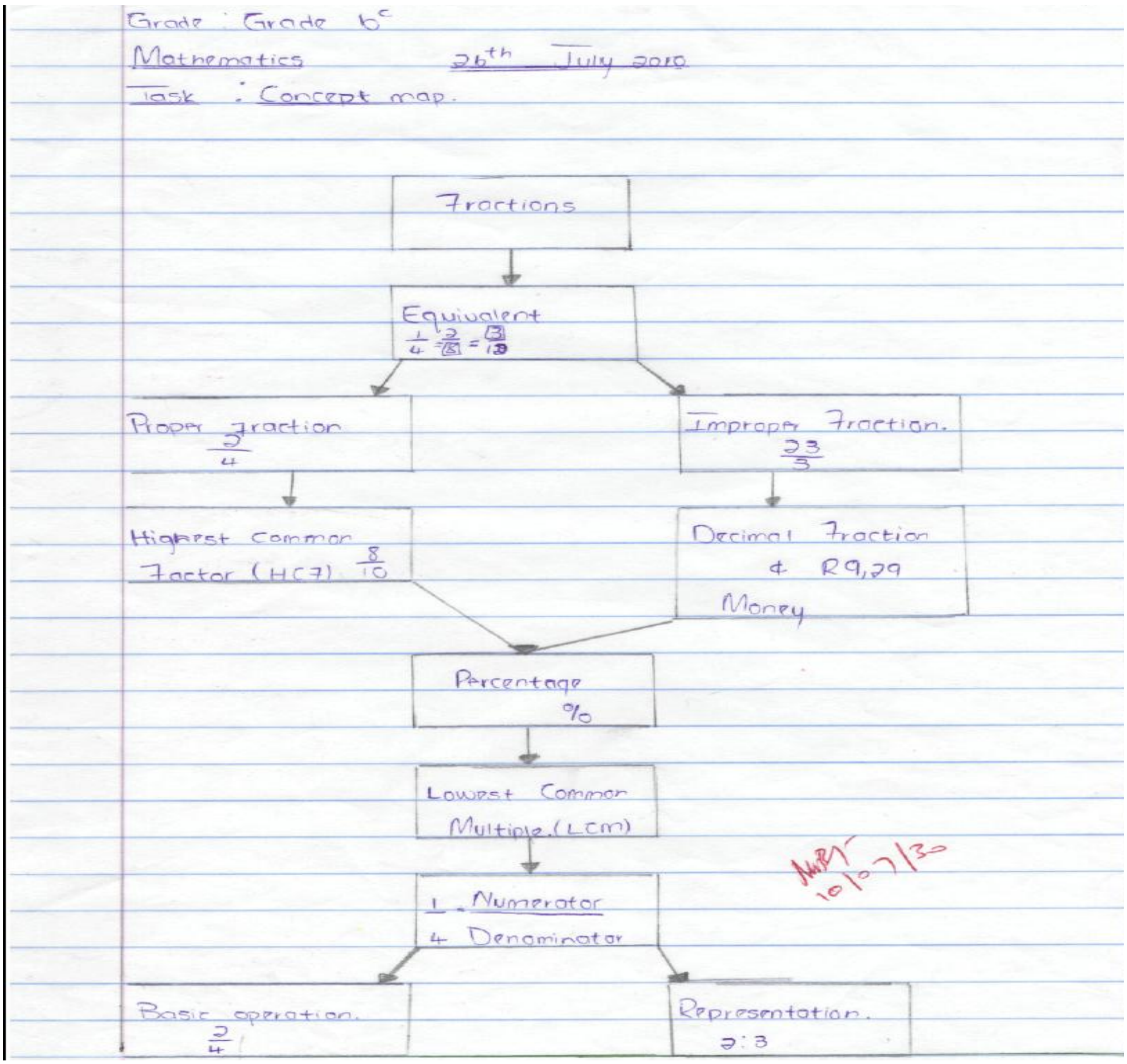
Fractions; decimal fraction; proper fraction; improper fraction; money; equivalent; basic operations; L.C.M.; numerator; denominator; ratio; percentages; simplified; representation; H.C.F.(highest common factor)

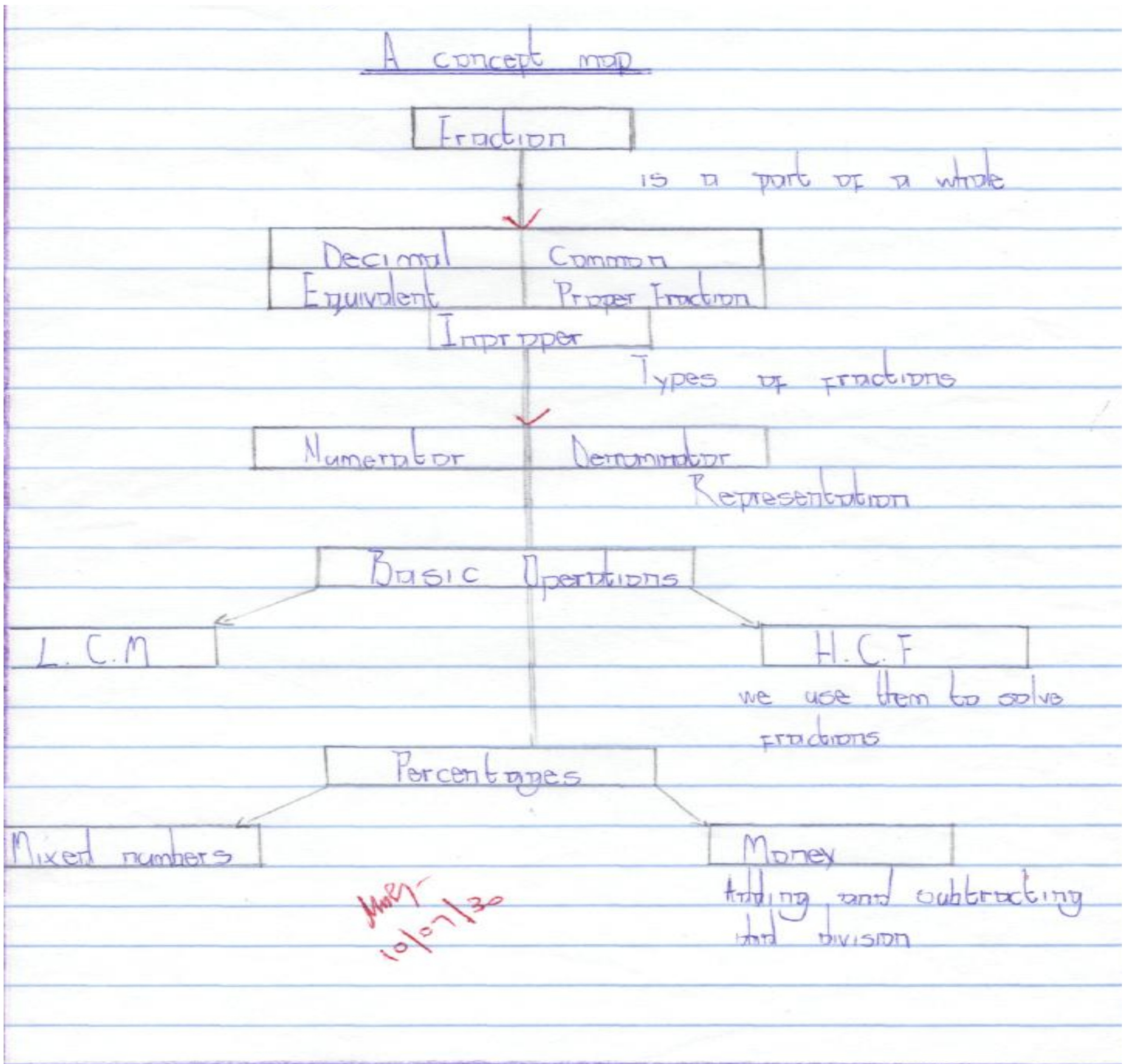
Appendix 2: Learner task 2

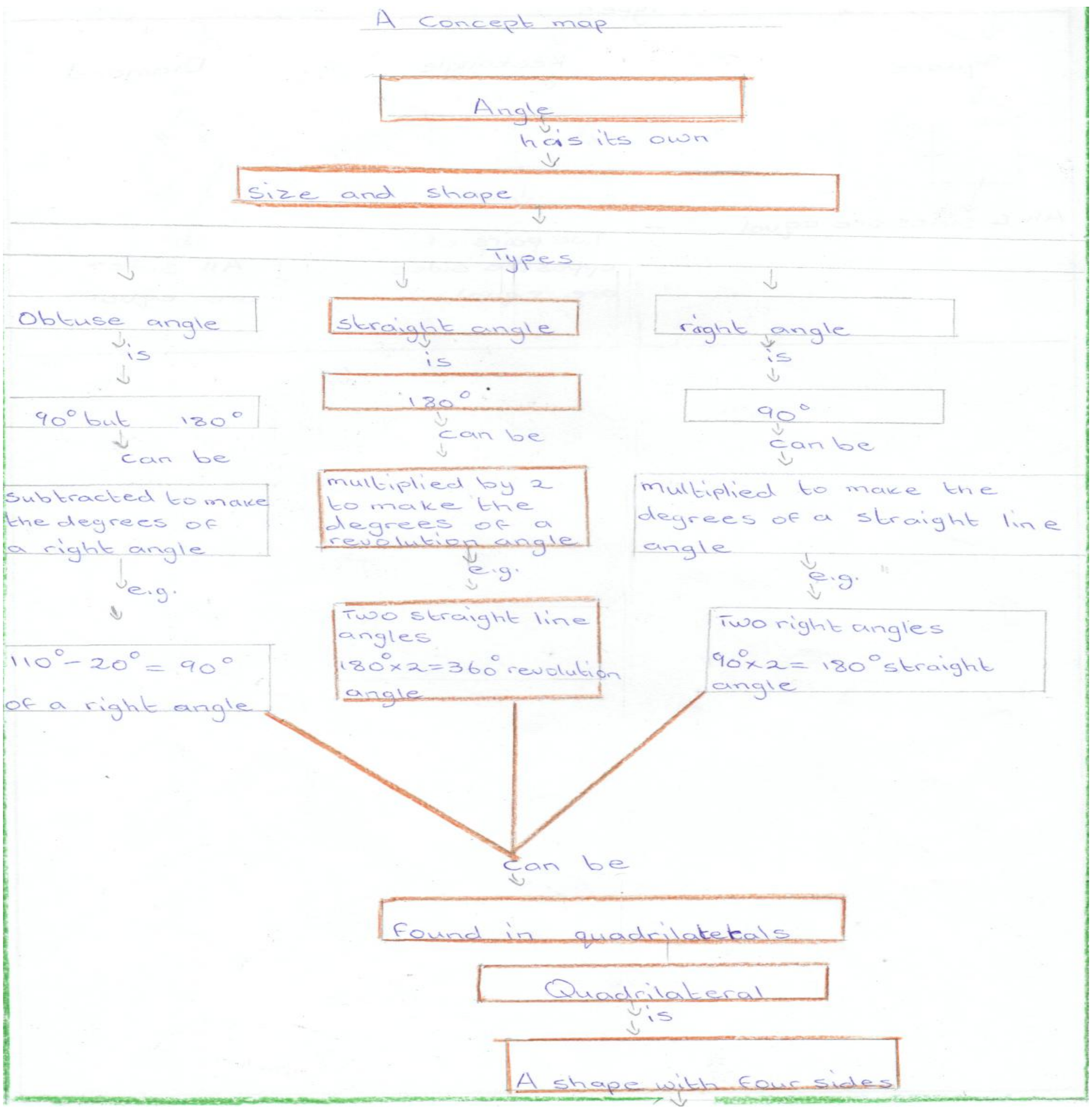
Using the following concepts, draw a concept map measurement; capacity; length; temperature; time; mm; ml; g; perimeter; volume; area; scale; thermometer; watch;square units.

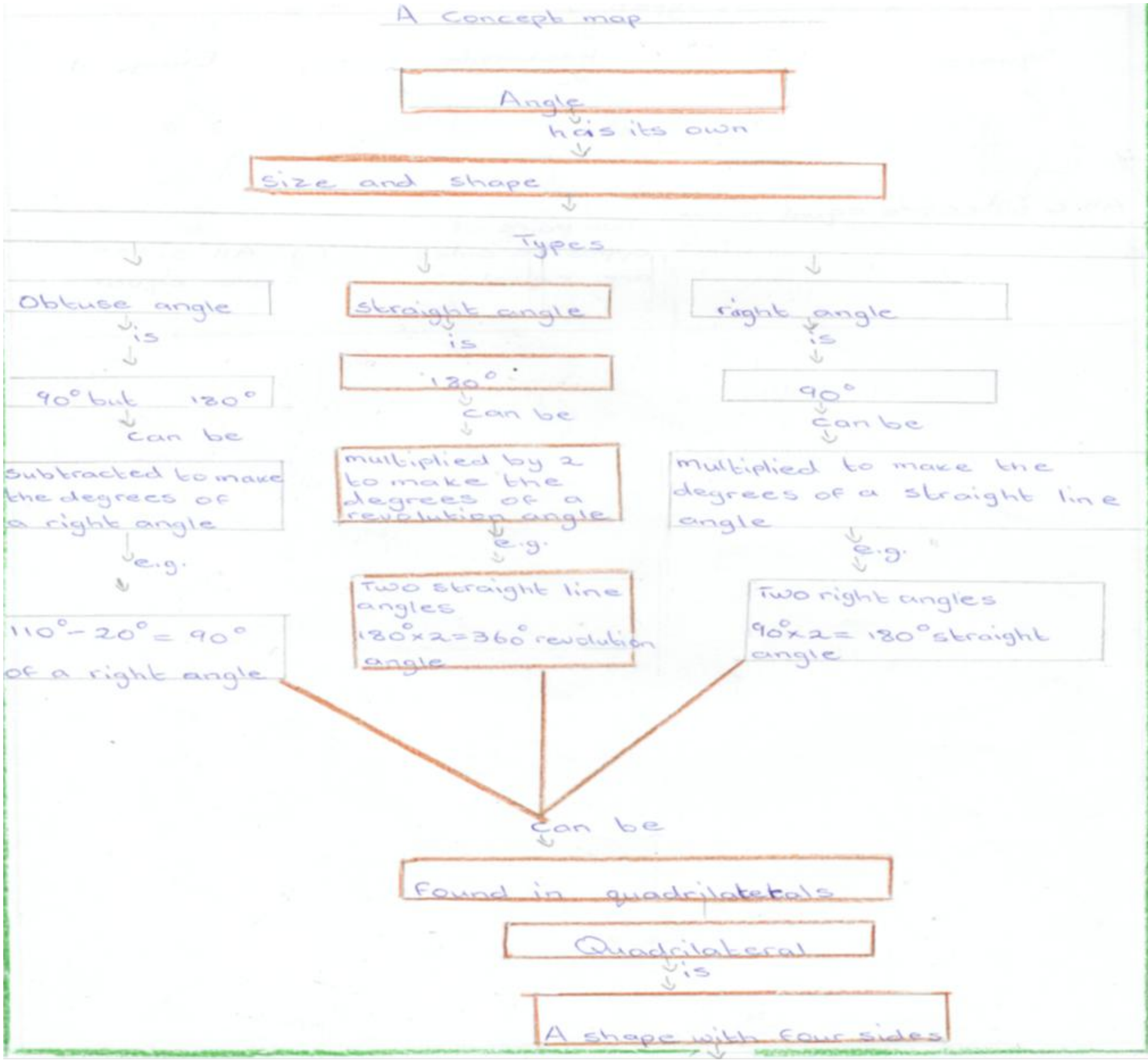
Appendix 3: Learner task 3

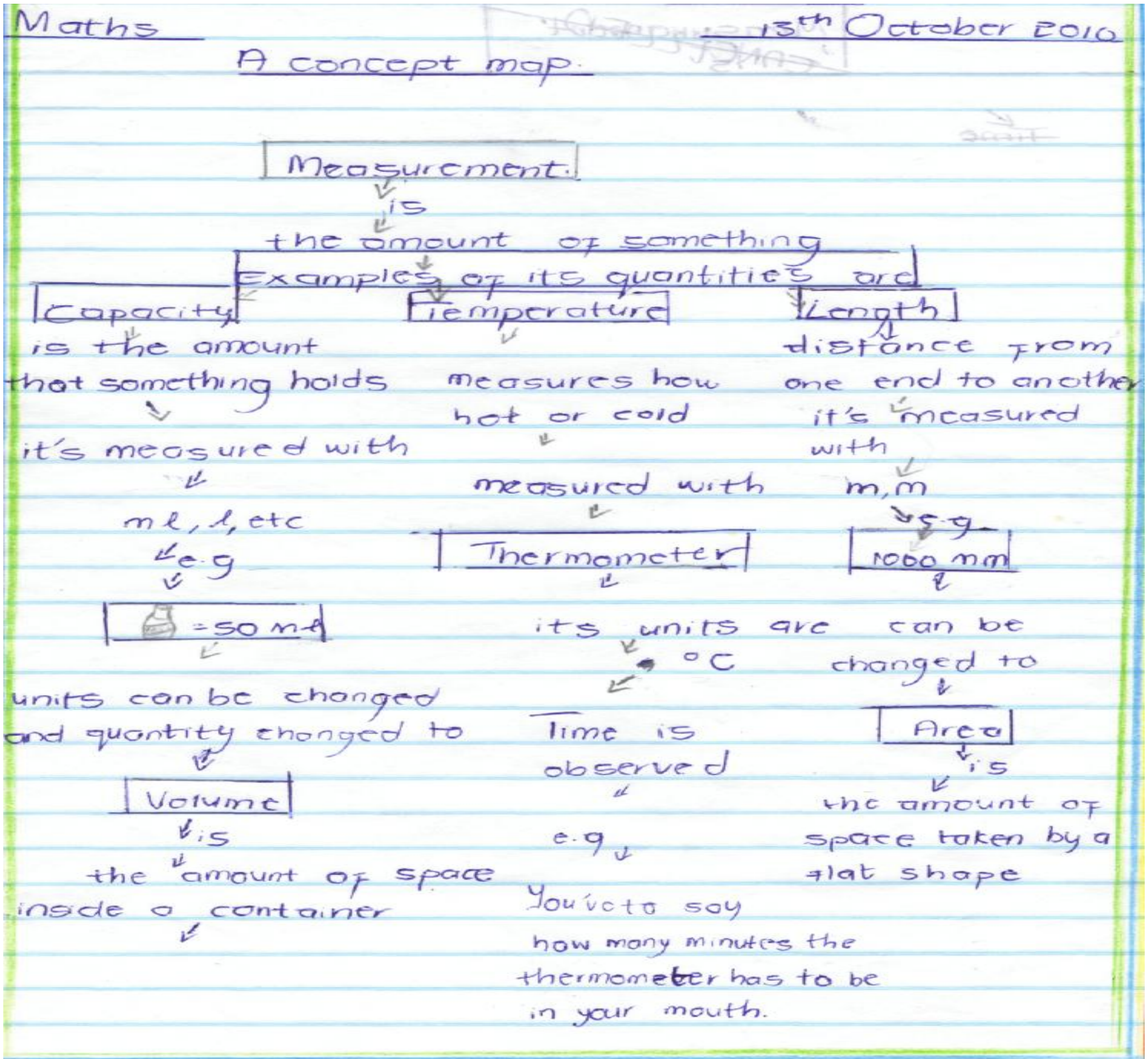
Use the following concepts to draw a concept map. Angle; obtuse angle; acute angle; right angle; straight angle; revolution; reflex angle; quadrilaterals; triangle; 180; 360; square; rectangle; rhombus; equilateral triangle; isosceles triangle

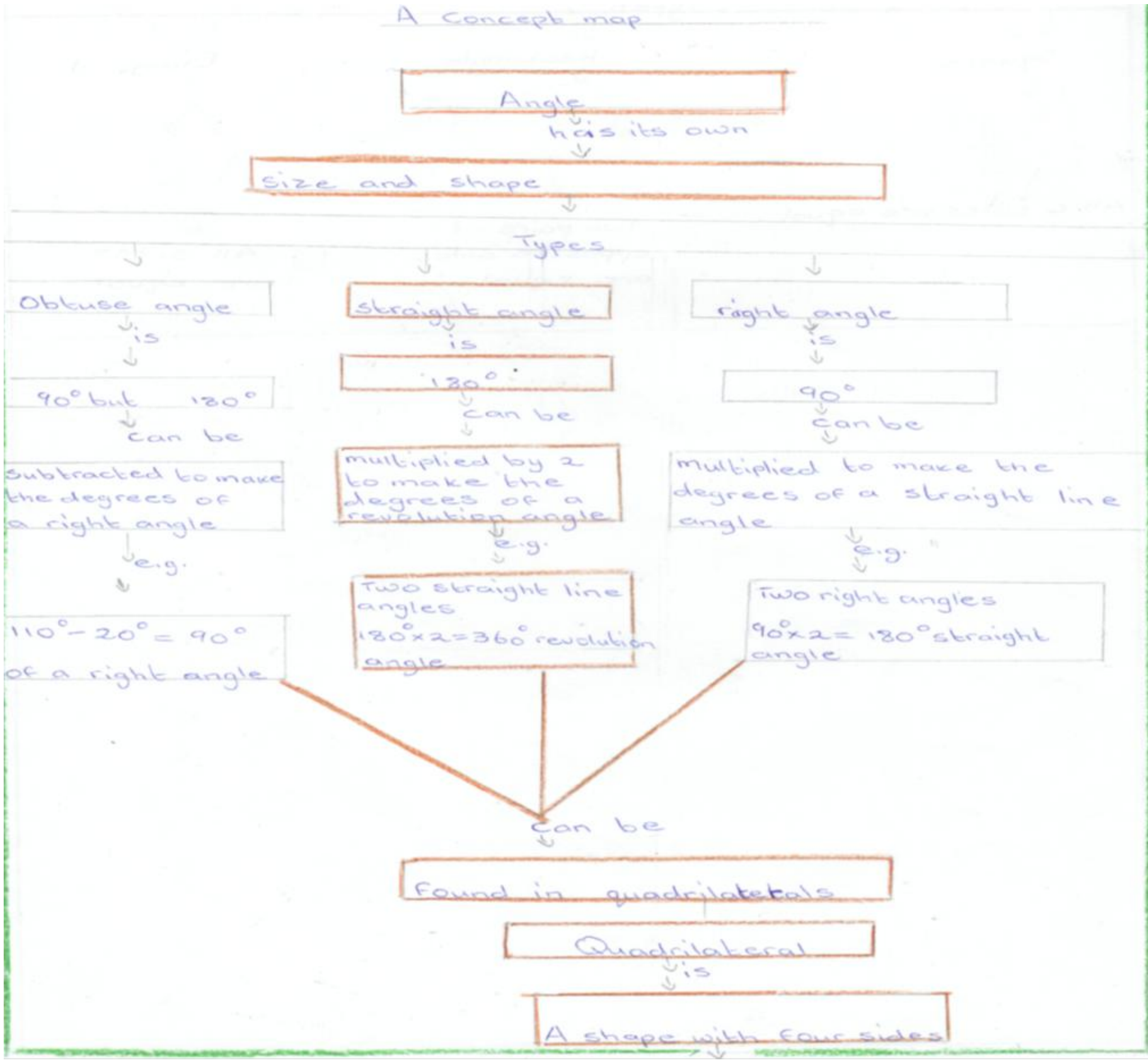

Grade : Grade 6c
Mathematics 26th July 2010
Task : Concept map.
Fractions
Equivalent
1/4 = 2/8 = 3/12
Proper fraction
2/4
Improper Fraction.
23/3
Highest common
Factor (HCF) 8/10
Decimal Fraction
& R9,29
Money
Percentage
%
Lowest Common
Multiple.(LCM)
1 Numerator
4 Denominator
Basic operation.
2/4
Representation.
2:3
10/07/30

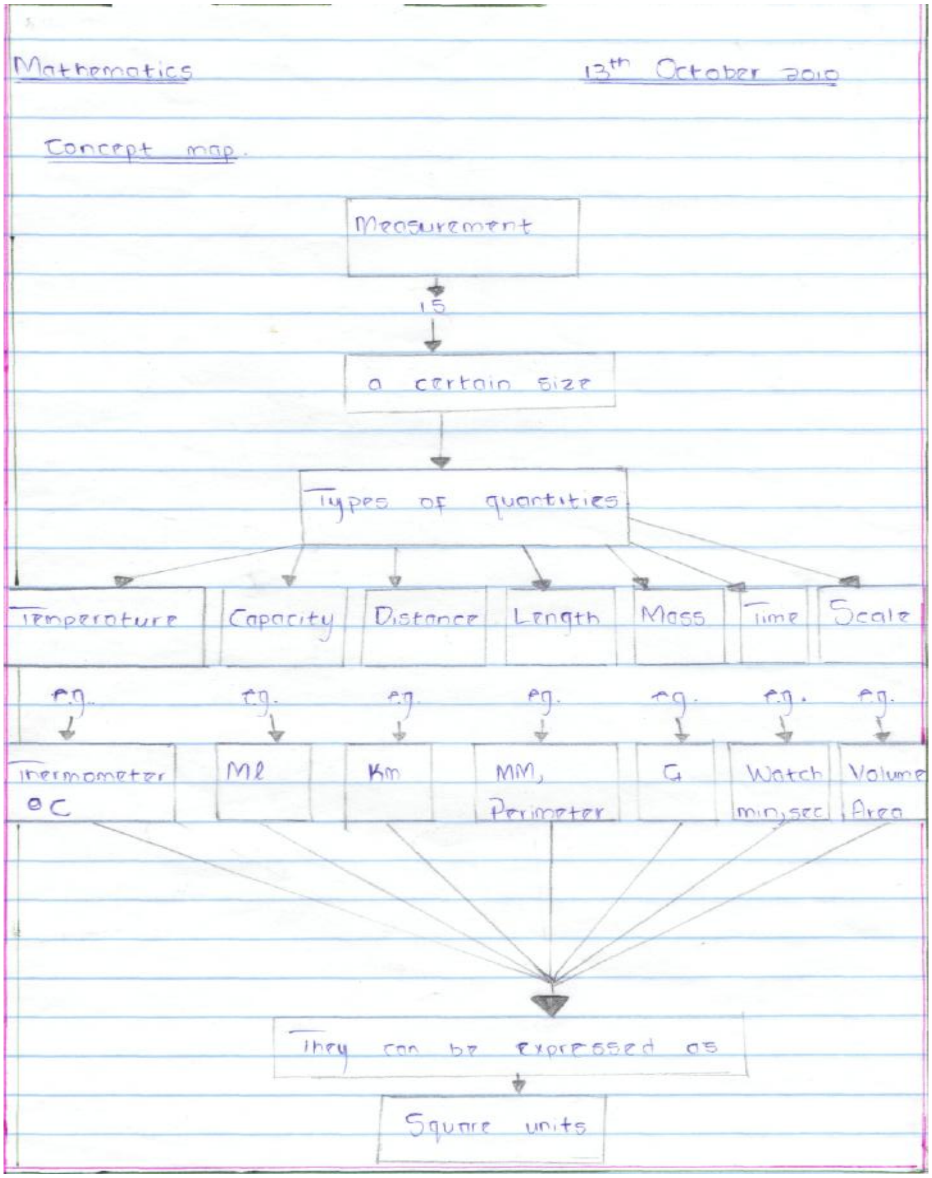

A concept map
Fraction
is a part of a whole
Decimal
Common
Equivalent
Proper Fraction
Improper
Types of fractions
Numerator
Denominator
Representation
Basic Operations
L.C.M
H.C.F
we use them to solve fractions
Percentages
Mixed numbers
Money
Adding and subtracting and division
10/07/30

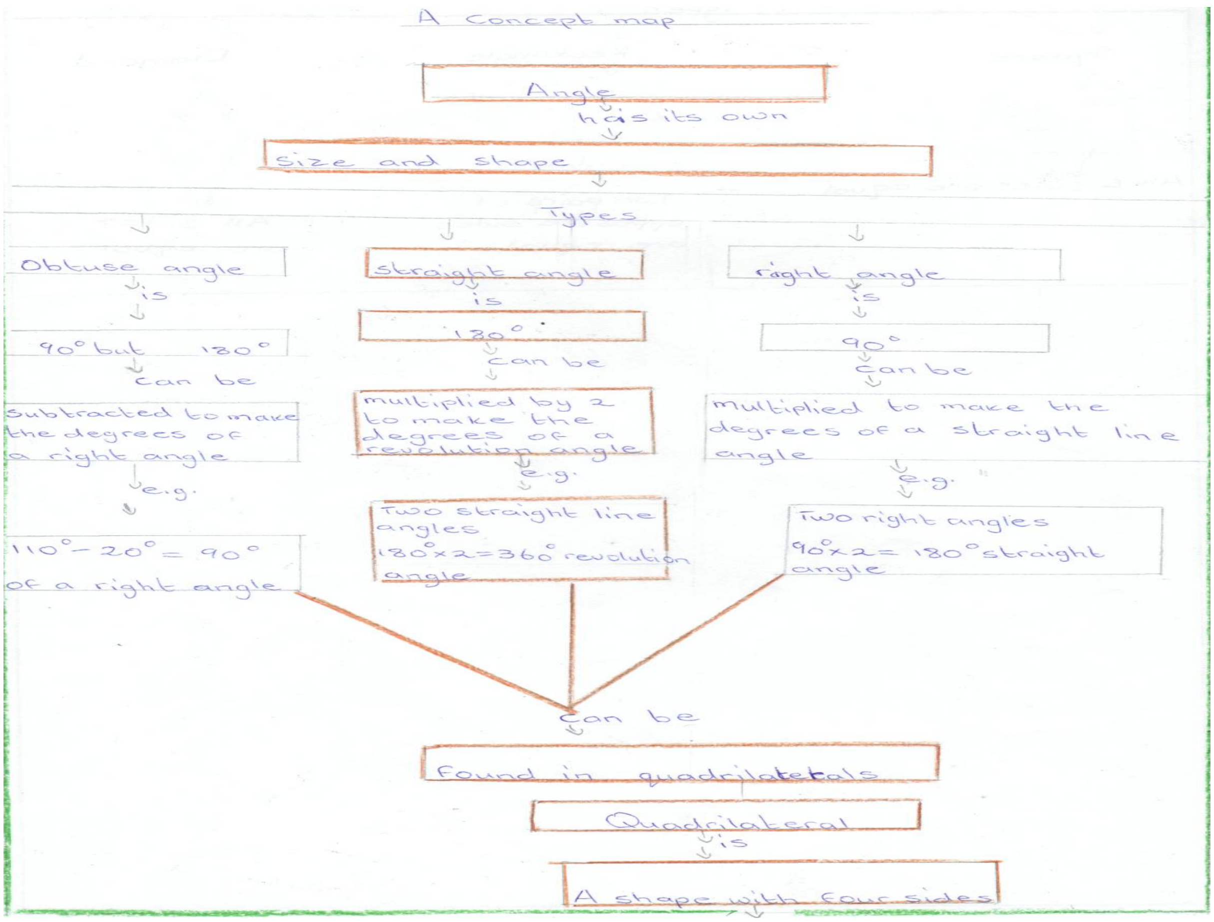

A Concept map
Angle
has its own
Size and shape
Types
Obtuse angle
is
90° but 180°
can be
subtracted to make the degrees of a right angle
e.g.
110° - 20° = 90° of a right angle
straight angle
is
180°
can be
multiplied by 2 to make the degrees of a revolution angle
e.g.
Two straight line angles 180°x2=360° revolution angle
right angle
is
90°
can be
multiplied to make the degrees of a straight line angle
e.g.
Two right angles 90°x2= 180° straight angle
can be
Found in quadrilaterals
Quadrilateral
is
A shape with four sides

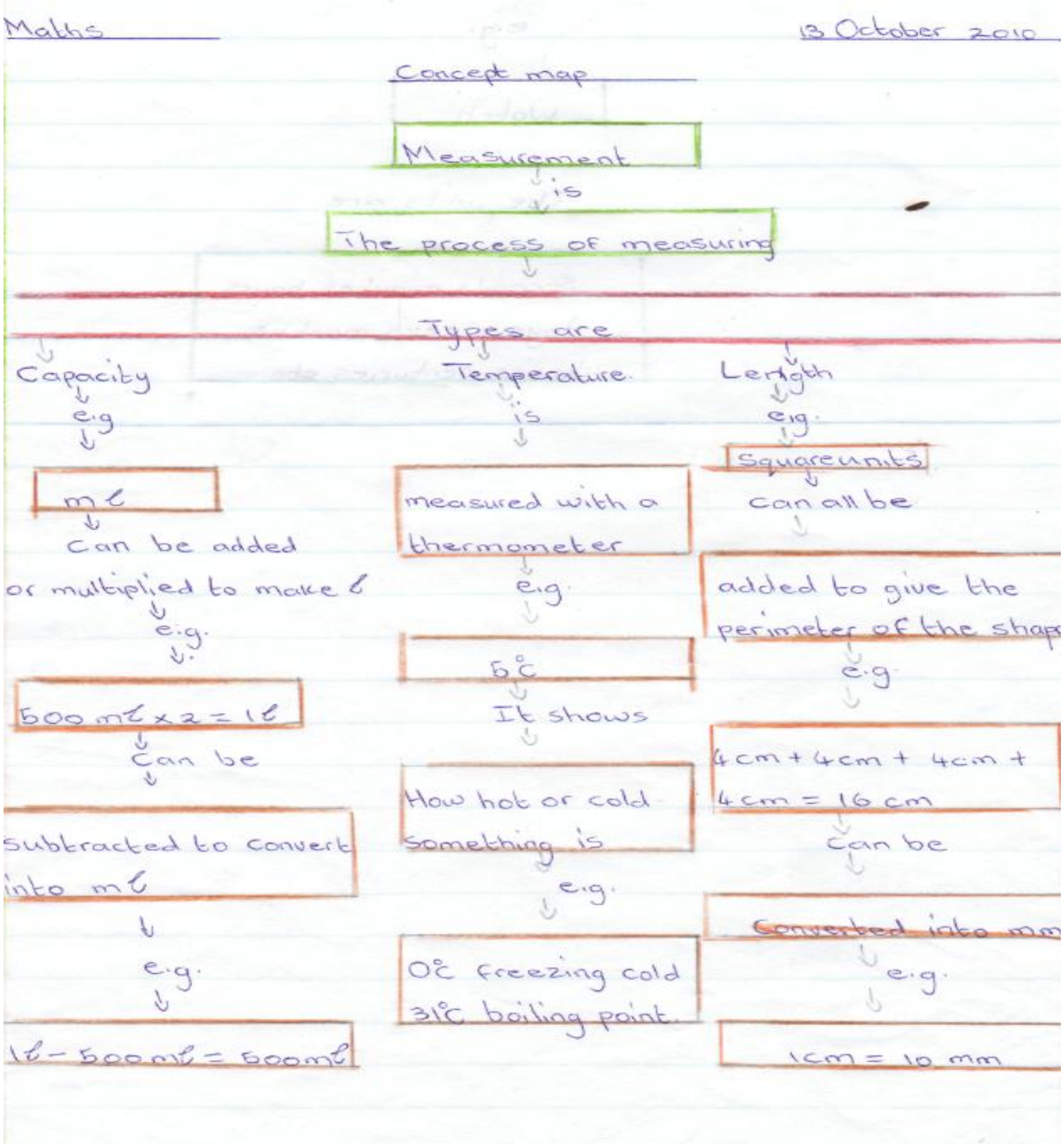

A Concept map
Angle
has its own
size and shape
Types
Obtuse angle
is
90° but 180°
can be
subtracted to make the degrees of a right angle
e.g.
110° - 20° = 90° of a right angle
straight angle
is
180°
can be
multiplied by 2 to make the degrees of a revolution angle
e.g.
Two straight line angles 180°x2=360° revolution angle
right angle
is
90°
can be
multiplied to make the degrees of a straight line angle
e.g.
Two right angles 90°x2= 180° straight angle
can be
Found in quadrilaterals
Quadrilateral
is
A shape with four sides

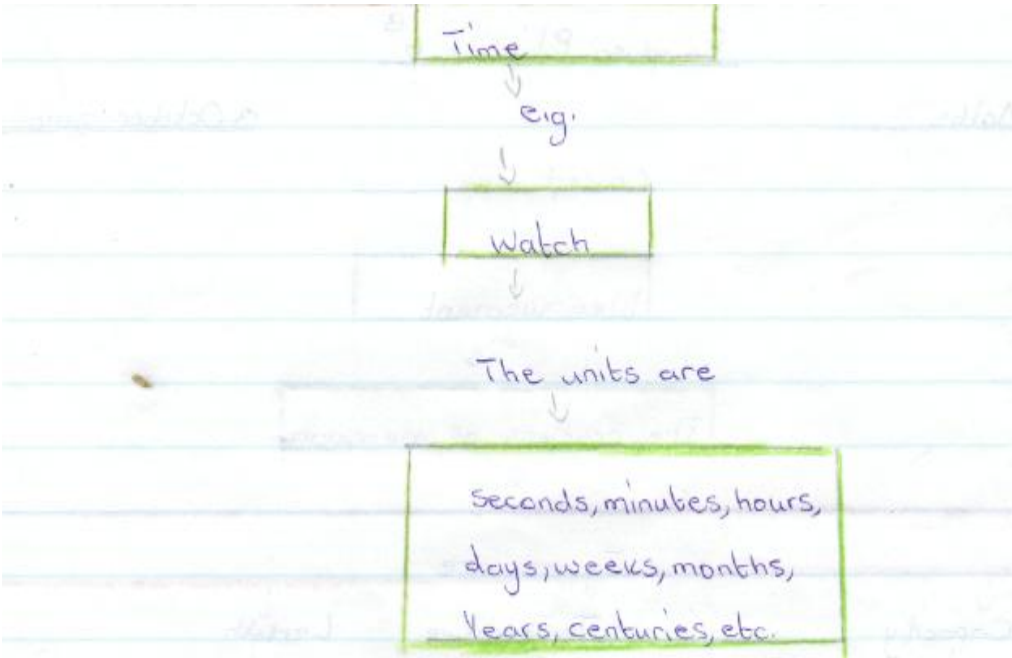

Maths
13th October 2010
A concept map.
Measurement
is
the amount of something
Examples of its quantities are
Capacity
is the amount
that something holds
it's measured with
ml, l, etc
e.g
= 50 ml
units can be changed
and quantity changed to
Volume
is
the amount of space
inside a container
Temperature
measures how
hot or cold
measured with
Thermometer
its units are
°C
Time is
observed
e.g
You've to say
how many minutes the
thermometer has to be
in your mouth.
Length
distance from
one end to another
it's measured
with
m, m
e.g
1000 mm
can be
changed to
Area
is
the amount of
space taken by a
flat shape


A Concept map
Angle
has its own
size and shape
Types
Obtuse angle
is
90° but 180°
can be
subtracted to make the degrees of a right angle
e.g.
110° - 20° = 90° of a right angle
straight angle
is
180°
can be
multiplied by 2 to make the degrees of a revolution angle
e.g.
Two straight line angles
180°x2=360° revolution angle
right angle
is
90°
can be
Multiplied to make the degrees of a straight line angle
e.g.
Two right angles
90°x2= 180° straight angle
can be
Found in quadrilaterals
Quadrilateral
is
A shape with four sides


Mathematics
13th October 2010
Concept map.
Measurement
is
a certain size
Types of quantities
Temperature
Capacity
Distance
Length
Mass
Time
Scale
e.g.
e.g.
e.g.
e.g.
e.g.
e.g.
e.g.
Thermometer
ºC
Ml
Km
MM,
Perimeter
G
Watch
min, sec
Volume
Area
They can be expressed as
Square units


A concept map
Angle
has its own
size and shape
Types
Obtuse angle
is
90° but 180°
can be
subtracted to make the degrees of a right angle
e.g.
110° - 20° = 90° of a right angle
straight angle
is
180°
can be
multiplied by 2 to make the degrees of a revolution angle
e.g.
Two straight line angles 180°x2=360° revolution angle
right angle
is
90°
can be
multiplied to make the degrees of a straight line angle
e.g.
Two right angles 90°x2= 180° straight angle
can be
found in quadrilaterals
Quadrilateral
is
A shape with four sides


Maths
13 October 2010
Concept map
Measurement
is
The process of measuring
Types are
Capacity
e.g
ml
Can be added
or multiplied to make l
e.g.
500 ml x 2 = 1l
Can be
subtracted to convert
into ml
e.g.
1l – 500 ml = 500 ml
Temperature
is
measured with a
thermometer
e.g
5°C
It shows
How hot or cold
something is
e.g.
0°C freezing cold
31°C boiling point.
Length
e.g.
Square units
can all be
added to give the
perimeter of the shape
e.g
4 cm + 4 cm + 4 cm +
4 cm = 16 cm
Can be
converted into mm
e.g.
1 cm = 10 mm


Time
e.g.
Watch
The units are
Seconds, minutes, hours,
days, weeks, months,
Years, centuries, etc.

Appendix 5: Interview schedule

T: what should concept maps have?

L:

T: Which other things you should always think about when you draw a concept map?

L:

T: What do you understand by the general term?

L:

T: Why do arrows have to be shown on a concept map?

L:

T: What are linking words?

L:

T: Do you find concept maps useful?

L:

Appendix 6: Excerpt of learners' interview transcripts

L3

T: What should concept maps have?
L: Boxes, lines, arrows.
T: Which other things you should always think about when you draw a concept map?
L: Describe words.
T: What are linking words?
L: They are describing words like "is".
T: What do you understand by the general term?
L: It is a bigger word which we write at the top and we write specific words under.
T: Why do arrows have to be shown on a concept map?
L: Because they show us the words which are related.
T: What is ml?
L: We use them to measure capacity.
T: What do we call this ml?
L: Units for measuring capacity.
T: You linked thermometer to temperature. What is thermometer?
L: It is the object used to measure temperature.
T: What are square units related to?
L: Measurement of a shape.
T: Do you find concept maps useful?
L: Yes because they help me to think a lot and revision for exam.

L1

T: What should concept maps have?
L: It must have boxes, general term, linking words and arrows.
T: Which other things you should always think about when you draw a concept map?
L: The general term
T: What do you understand by the general term?
L: It is a word which we write on top.
T: Why do arrows have to be shown on a concept map?
L: They show us the words which go together.
T: What are linking words?
L: The linking words join words.
T: Are temperature, capacity and length examples of quantities?
L: No, they are types of quantities we can measure.
T: How can we change millimetres to area?
L: No teacher (shaking her head) we cannot change millimetres to area because area is the amount of space taken by a shape and millimetres is the units of length.
T: Is it possible to have only words or concepts that are given in the word bank?
L: No, you can have your own words which do not appear on the list.
T: Which quantity shows how heavy an object is?
L: It is mass.
T: Which units are used to measure mass?
L: Kilograms.

T: Do you find concept maps useful?
L: Yes, because concept maps help us in revision and we can learn more.