THE EFFECTS OF LEARNING STYLES ON GRADE 11 LEARNERS' PERFORMANCE IN MATHEMATICS AT ONE SENIOR SECONDARY SCHOOL IN THE OSHANA EDUCATION REGION

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APPROVAL PAGE

This research has been examined and approved as meeting the required standards for partial fulfilment of the requirements of the degree of Master of Education.

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DECLARATION

I, Patemoshela Ndadilepo Silas, declare hereby that **"***The effects of learning styles on the Grade 11 learners' performance in Mathematics in the Oshana Education Region***"** is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree at any other institutions of higher education.

……..……. ……...

Patemoshela Ndadilepo Silas Date

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I would like to thank God who still gives me the inspiration and vision to make a difference, '…your word is a lamp to my feet and a light to my path…..' Psalm 119:105.

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DEDICATION

This thesis is dedicated to my mom, Cecilia Hendjala and my beloved daughters Grace, Peya and Gift.

ABSTRACT

This study investigated the effects of learning styles on the performance of Grade 11 learners in Mathematics at one of the secondary schools in the Oshana education region. The study used both qualitative and quantitative approaches and it was carried out for four weeks. Using Kolb's (2005) Learning Style Inventory, learners' learning styles were identified and the learners were then grouped according to their learning styles as converging, diverging, assimilators and accommodators.

All the four experimental groups were pre-tested to determine whether all the groups were on par prior to the study in Algebra by the researcher. Each learning style group was placed in a different classroom and taught the same content using suitable teaching methods for each group and then post-tested. Post-test scores showed a significant difference in the performance of the Grade 11 learners and their learning styles. Structured interviews were also used to get views from the three Mathematics teachers about learning styles. The Mathematics teachers indicated that considering that learners learning styles were time - consuming and had led to less content being covered at the end of the day. The findings suggest that Mathematics teachers should familiarise themselves with knowledge and skills of dealing with different learners' learning styles and incorporate these in the teaching of Mathematics. The study also recommends that Mathematics teachers should provide the learners with a variety of activities, in order to enhance the development of different learning styles in their learners.

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LIST OF ACRONYMS

BETD	Basic Education Teacher Diploma
DNEA	Directorate of National Examinations and Assessment
MBESC	Ministry of Basic Education, Sport and Culture
NIED	National Institute for Educational Development
NSSC	Namibian Senior Secondary Certificate

CHAPTER 1: INTRODUCTION

Background of the study

Just as individuals differ in height, weight, metabolism, personal interests, and other characteristics, learners also differ in how they learn, the rate at which learning occurs, and the cognitive styles they prefer for learning new material (Hamachek, 1995). Hamachek further states that teachers realize that in order to assist pupils and to capitalize on their natural inclination to understand, one must not only diagnose their learning style, but also accept their learning styles.

Keefe (2000) defines learning styles as the cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Cognition is not a single entity of which the researchers, such as James, Gardner, & Kolb (1995), Montgomery (1996) and Mumford & Honey (2000) have varied views on the exact components and characteristics of learning styles. Chris (1998) defined learning styles as types of learning activities and tasks which learners prefer to experience and which they feel are more effective in promoting their own learning. The question that this study sought to address was; What effects do learning styles have on Grade 11 learners' performance in Mathematics?

James, Gardner, & Kolb (1995) state that learning styles have been acknowledged as the prime constructs that serve as relatively stable indicators of how learners respond to the learning environment. However, with variation, these stable indicators may change as the learners adapt to the learning approach, progress and respond to the problems (Montgomery, 1996).

Research conducted by Yazici (2011) on the effects of learning styles on the performance of students at Istanbul Kultur University in Turkey indicated that, academic performance of students was consistent with their learning styles.

The Namibian education system shifted from a traditional teacher-centred to a learner-centred education after independence (Angula, 1993). This type of education system has led to an increased interest in learners' individual differences. The "new" paradigm learner-centred education is based on inclusiveness, cooperative learning, and encourages diversity. James, Gardner, & Kolb (1995) claimed that learners consistently show positive improvements in performance when the content concepts are illustrated in their preferred learning style.

The Ministry of Basic Education, Sport and Culture (MBESC) (1994) states that a wide range of differences in learning among learners whether in urban or rural areas may influence ways in which learners learn. Yet, some teachers seem not to acknowledge the significance of considering individual learning styles in planning the lessons. Research on the effects of learning styles on the learner academic achievement has been conducted worldwide (Yunyan, 2004; Daniel, Price, & Merrifield, 2002; Dunn, Beaudry, & Klavas, 2001; Smoak, 2007; Ginthier & Caldwell, 2003), but, none has been carried out in Namibia to investigate the effects of learning styles on the performance of Namibian learners in Mathematics.

Nonetheless, the results on learning styles are not conclusive (Rautopuro & Vaisanen, 2003). They noted that the learning styles do not seem to have any effect on the performance of learners in different school subjects while other researchers

(Bell, 1998; Yunyan, 2004; Sandmire & Boyce, 2004) stated that there is a significant difference between learning styles and achievement in the school subjects. These studies did not indicate the extent to which teachers should incorporate learning styles in planning their lessons, therefore calls for further investigation on learning styles.

Theoretical framework

This study draws upon Kolb's (1984) model of learning styles based on the "Experiential Learning Theory" which is one of the most widely used models for identifying the learning styles of individuals. Kolb's (1984) model suggests that knowledge is generated by grasping and transforming experience. It also states that there are two modes of grasping experience namely; Concrete Experience (CE) and Abstract Conceptualization (AC), and two modes of transforming this experience namely; Reflective Observation (RO), and Active Experimentation (AE) (Kolb, 1984, p. 11). Kolb further states that the learning process can be visualized as a recursive cycle with the phases of experiencing, reflecting, thinking, and acting. Immediate or concrete experiences are the basis for observations and reflections. The latter are assimilated and distilled into abstract concepts from which new implications for action can be drawn (Kolb, 1984). These implications can be actively tested and serve as guides in creating new experiences.

Kolb (1984) further states that individuals tend to favour and develop one mode of grasping experience and one mode of transforming experience, which eventually shape their learning styles. Kolb also says individuals can adopt four learning styles,

depending on their approaches for grasping and transforming experience namely; converging (AC+AE), diverging (CE+RO), assimilating (AC+RO) and accommodating (CE+AE).

According to Yunyan (2004), Kolb's learning theory has been widely used to explore the learning styles of undergraduates in Turkey (Bilket University & Istanbul Kultur University) and school learners in an urban South Eastern high school in Columbia and Sourthern Carolina. Both Graduates and learners were classified into four learning styles according to their preferences of cognitive stages of learning: accommodating, diverging, assimilating, and converging. This study used Kolb's learning theory as a theoretical framework because his theory, "shares a common view that learning is a process whereby concepts are derived and continuously modified by experience" (Yunyan, 2004, p.8). In the context of this study, Kolb's Learning Style Model was a suitable framework because it was used as the backbone for this study to explain how individual learners learn and what effects individual learning styles have on learners' performance in Mathematics at one Senior Secondary School in the Oshana Education Region.

Statement of the problem

Throughout the researcher's teaching period at the school where the study was conducted, she observed that the Grade 11 learners had been performing poorly in Mathematics. The school was ranked at position 56 out of 161 schools in the year 2009 and position 34 out of 161 schools in the year 2010 in the National

Mathematics Results (Directorate of National Examinations and Assessment [DNEA], 2010). The poor performance in Mathematics, among others, is attributed to the instructional approaches employed by teachers (National Institute for Educational Development [NIED], 2010).

Furthermore, NIED suggests that teachers should adjust their teaching approaches in teaching to cater for all types of learners in their classrooms. Teachers are therefore being encouraged to design instructions that involve the active participation of learners in the learning process. It is against this background that this research was conducted in order to find out the effects of learning styles on the performance of Grade 11 learners in Mathematics at one Senior Secondary School in the Oshana Education region.

Questions of the study

The study addressed the following four questions and one hypothesis:

1. What are the different learning styles utilized by the Grade 11 learners at one Senior Secondary School in learning Mathematics in Oshana Education Region?
2. What effects do the identified learning styles have on the Grade 11 learners' performance in Mathematics?
3. What methods do Mathematics teachers use to identify learners' learning styles?
4. To what extent do Mathematics teachers design teaching methods based on the learners' learning styles?

Hypothesis

H_o: There is no significant difference in the learners' performance in Mathematics and their learning styles.

H_1: There is a significant difference in the learners' performance in Mathematics and their learning styles.

Significance of the study

The results of this study are important to all teachers, learners, novice teachers, and researchers in Mathematics education. It might help teachers to develop more efficient and effective instructional methods based on learners' learning styles. The results might also help teachers to be aware of each learner's learning style and plan their lessons to cater for different types of learners in their classrooms. Apart from that, the results might help the learners to experience other modes of learning which might enhance their performance. Furthermore, the results might help the learners to understand their own learning styles and hence enhance the way they acquire knowledge.

The results might also serve as a useful tool for other researchers who might be interested in carrying out further research on the effects of learning styles on the learners' performance in Mathematics in other Educational Regions and other subject areas.

Limitations of the study

The success of data collection of this study depended heavily on the cooperation and willingness of the participants, both learners and teachers to participate. Without their full cooperation, there would hardly be any relevant and reliable data collected.

Finances were another limitation of this study. The researcher had limited financial resources, and as such did not travel to other schools.

The results of this study may not be generalised to other schools since it was based on the study of one Senior Secondary School in the Oshana Education Region.

Delimitations of the study

This study was carried out with the Grade 11 Mathematics learners and Mathematics teachers at one Senior Secondary School in the Oshana Education Region.

Definition of terms

For the reader's clarity, the following terms used in this study are defined here.

Learning styles: Refers to the types of learning activities and tasks which pupils prefer to experience and which they feel are more effective in promoting their own teaching (Chris, 1998). In this study, it refers to the personal choice of a learner in which to perceive and process information.

Converging: Refers to the learners who prefer to deal with technical works or problems to social relations (Kolb, 1993). In this study, it refers to the learners who

are less concerned with other learners and interpersonal aspects and like to work alone.

Assimilating: Refers to individuals who perceive information abstractly and process it reflectively (Yunyan, 2004). In this study, it refers to individuals who prefer to deal with abstract concepts and topics alone rather than interacting with other people.

Diverging: According to Yunyan (2004), diverging learners typically perceive information concretely and process it reflectively. In this study, it refers to the learners who are able to see concrete situations from different perspectives.

Performance: Performance refers to results and their outcomes obtained from processes, products, and services that permit evaluation and comparison relative to goals, standards, past results, and other organisations (Mwamwenda, 1995). In this study, it refers to the learners' results from the tests or examinations which were given to them.

Individual differences: Individual differences refers to the ways in which individuals differ in their behaviours (Chris, 1998). In this study, individual differences refers to a learner's personal characteristics that can affect the way s/he learns. E.g. likes, dislikes, interests as well as values.

Algebra: In this study, it refers to a set of letters and numbers connected by addition, subtraction, multiplication or division. It is a branch of Mathematics at Grade 11 – 12

level in which arithmetical operations and relationships are generalized by using alphabetic symbols to represent unknown numbers or members of specified sets of numbers (D'Emilio, 2010).

Summary

This chapter gave the background information of the study on the effects of learning styles on the learners' performance. The effects on learning styles have been conducted world wide but it seems none have been conducted in Namibia. The study draws on Kolb's (2005) model of learning styles based on Experiential Learning Theory. The school selected for study was ranked at position 56 out of 161 schools in 2009 and position 34 out of 161 in 2010 in National Mathematics Results. Therefore, the study attempted to find out whether there was a significant difference between the Grade 11 learners' performance in Mathematics and their learning styles.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the literature on the different types of learning styles used by learners to study school subjects, the effects of learning styles on the performance of learners in school subjects and the methods used to identify the learners' learning styles as well as the extent to which teachers can prepare the lessons based on the learners' learning styles. The researcher was unable to find studies on learning styles done in Namibia. The study thus reviewed international studies on learning styles and their effects on academic performance.

Definition of Learning Styles

Yunyan (2004) defined learning styles as the manner in which a combination of physical, psychological, emotional, sociological and environmental factors affect an individual's ability to perceive, interact with and respond to the learning environment, which is often used in special education. Montgomery (1996) identified a learning style as learners' preferred instructional technique, curriculum content, and their preferred response to appropriate feedback from their teachers. In spite of the different definitions, Yunyan (2004) and Montgomery (1996) classified learners into different categories in order to study the individual learning differences.

Different types of learning styles

Hamachek (1995) stated that each person develops a particular style or preference for approaching new learning. He outlined three general learning styles namely; visual (reading), aural (listening), and physical (actively doing things). Some learners can learn best by listening to lecturers or discussions; others find their learning is

facilitated by reading, reviewing notes, scanning books while other learners learn more through active physical involvement such as performing experiments rather than reading about them (Hamachek, 1995).

Farrant (2002) identified two ways in which learners learn namely: deductive learning that describes the process by which a learner is presented with a hypothesis or general principles and applies a number of tests to it to discover whether it is true or not. The second way is inductive learning which involves the process of learning by example where a system tries to induce a general rule from a set of observed instances. As a result some learners examine related matters to find if any general conclusion can be drawn.

Parsons, Hinson, & Sardo-Brown (2001) state that learning styles appear to be biological and perhaps socialized differences that influence classroom learning in particular and lifelong learning in general. They further state that learners use many types of learning styles to master their content such as psychological learning style, physiological style and cognitive styles. The learning of the psychological learning style of learners is influenced by their inner strengths and their individual senses. Psychological elements are motivational processes and are preferential in nature.

According to Parsons et al. (2001), physiological style is a consistent way to facilitate learning using the sense or environment stimuli. Physiological elements are rooted in learners' reactions to the environment in which they live**.** Parsons et al. (2001) further stated that cognitive styles are the consistent ways of responding to the

stimuli in the environment, how things are perceived and made sense of and the pleasurable ways for processing information. Cognitive elements are internal to information processing habits**.** These three learning styles indicate that as the learners' thinking capacity grows, they become more sophisticated and they can easily choose their best way of learning (Parsons et al., 2001). In other words, learners prefer learning styles that influence their performance based on their experience.

Dunn & Dunn (2006) defined a learning style as the way in which each learner begins to concentrate on process, absorb and retain new and difficult information or skills. Dunn & Dunn (2006) came up with the Dunn model which identifies three learning styles, namely; auditory, visual and tactile/kinesthetic. These three learning styles are defined and explained more in detail as follows:

Auditory learning style learners prefer to use their voices and ears to learn. They remember what they hear and what they themselves say aloud (Dunn & Dunn, 2006). They learn best through verbal lectures, discussions, talking things through and listening to what others have to say. They seem to thrive on working and talking with others. These learners often benefit from reading text aloud and using a tape recorder.

Visual learning style learners prefer to process information by seeing it. They like to receive information from pictures, graphs and visual media (Dunn & Duun, 2006). These learners frequently close their eyes to reassemble a picture of what they are

trying to remember. During a lecture or classroom discussion, visual learners often prefer to take detailed notes to absorb the information.

Tactile/Kinesthetic learning style learners always want to be as active as they can. They tend to learn better when they have the opportunity to touch or manipulate in some way (Dunn & Dunn, 2006). Role play, field trips, and movement activities can accommodate kinesthetic learners. These learners may find it hard to sit still for long periods and may become distracted by their need for activity and exploration.

The three learning styles identified in the Dunn model (Dunn & Dunn, 2006) link well with the learning styles identified by Yunyan (2004), Farrant (2002) and Hamacheck (1995). All the four researchers categorised learners into different learning styles although differently stratified. According to Yunyan (2004), Farrant (2002) and Hamacheck (1995), some learners prefer to read rather than listen, work alone rather than in groups, find things out for themselves rather than being given summaries by the teacher and some like to have tasks tightly prescribed rather than left to their own decision making.

Effects of learning styles on the learners' performance in different courses

Daniel, Price, & Merrifield (2002) studied the effects of learning styles on learners' success in web-based learning environments where learners were placed into two learning styles groups (diverging and assimilating). The results showed that diverging learners received high scores in web-based learning environments while the assimilator learners received low scores. Daniel et al. (2002) concluded that the type of learning style had no significant effects on the learners' achievement in different learning environments for both diverging and assimilating learners. What

matters the most is the way learners learn but not necessarily the environments in which they are.

In a research conducted by Dunn, Beaudry, & Klavas (2001) at the University of Hamburg in German, the findings showed that motivation, learning strategies and learning styles affect academic performance. Dunn et al. (2001) further indicated that learning in partially matched conditions is significantly superior to learning in mismatched conditions. Perhaps more importantly is to give the learners the hope and self-confidence by using their individual strengths and styles so that they can be successful in the classroom.

Entwisle, Alexander, & Olson (2004) argue that incorporating the learners' learning style into classroom practice offers an opportunity to the learners to differentiate current school experience from the previous school experience, leading to knowledge discoveries. As learners make new discoveries in the learning process, they incorporate this information into classroom settings and their daily lives' practices.

Smoak (2007) espouses the belief that accommodating learners' learning styles increases achievement. She cited various studies that yielded significant gains in academic performance. One of the studies she cited was carried out by Carbo (2000) in one elementary school in Bloomington in an urban area. According to Carbo the school had incorporated the learning styles in classroom instructions and this had changed the learners' academic performances dramatically from weak to good. Smoak (2007) further stated that prior to incorporating learning styles, this school was ranked 61st out of 65 elementary schools in the district, but after incorporating

the learning styles in classroom instructions for two years, the learners' performance was positively affected and the school rose to 9th place in the district.

Smoak (2007), and Ginthier & Caldwell (2003) found a high correlation between a combination of learning style variables (motivation, persistence, responsible, kinesthetic and teacher motivation) and low achievement in the disadvantaged socio-economic groups. They suggested that the teachers should adopt strategies, which allow learners greater control over their learning processes, increasing motivation and their achievement. Smoak (2007) and Ginthier & Caldwell (2003) also suggest that teachers should consider low achieving learners' learning styles into lesson planning. This might improve their performance, particularly those learners from disadvantaged socio-economic backgrounds.

Ginthier & Caldwell (2003) stated that the African-American education system has been consciously acknowledging teachers for paying attention to the cultural diversity of their learners. Some of the acknowledged teachers become relaxed and failed to create a conducive learning environment for the learners, and this affected the learners' performance negatively. Ginthier & Caldwell (2003) therefore, concluded that failure to recognize the learning environments to consider the unique characteristics of the learners' learning preferences might not provide a solid foundation for their education success.

Philbin, Meier, Hurffman, & Boverie (1995) researched the innate learning styles of male and female learners in Lakewood elementary school in Minnesota. They

concluded that traditional teaching methods favour males' preferred learning styles of analytical and abstract thinking while ignoring the preferred female learning styles of comprehensive and concrete thinking. Furthermore, Philbin et al. (1995) noted the gap in Mathematics achievement between males and females, and postulated that the learning style differences between the two genders may contribute to the achievement discrepancy.

While attention has been given to the differing learning styles of learners (Ginthier & Caldwell, 2003; Philbin et al., 1995; Smoak, 2007), other researchers and theorists (Heimlich, & Norland, 2002; Warren, 2001) turned their attention to the learning styles of teachers and how they affected classroom practice. The teaching behaviours reflect the beliefs and values that teachers hold about the learners' role in the exchange of information (Heimlich, & Norland, 2002). Teachers' classroom attitudes and teaching methods reflect their own prior experience in the learning process. Many teachers have themselves been taught in a field dependent environment and their tendency is to continue this practice even though intellectually they recognize that this is not the preferred learning style of many of their learners (Heimlich, & Norland, 2002).

Warren (2001), sought to quantify the effects of matching learners' learning style with teachers' learning style. Her study involved 57 ninth-Grade learners and 16 ninth-Grade teachers in an urban South Eastern high school in Columbia. After determining the 13 global or analytical preferences of both teachers and learners, Warren tracked learners' achievement in English, Mathematics, Science, and Social

Studies classes. She found that nearly seventy-five percent of learners performed better academically when paired with teachers possessing the same global or analytical style.

De Smedt, Swillen, Verschaffel, & Ghesquière (2009) have questioned why and how an awareness of one's learning style should be thought to have a positive effect on the quality of one's learning. They conclude that learning style awareness is only a 'cognitive in the wheel of the learning process' and that 'it is not very likely that the self-concept of a learner, once he or she has reached a certain age, will drastically develop by learning about his or her personal style'. Greater awareness of their own (learners) dominant learning styles can help teachers to provide learning activities that are more inclusive of the other styles and which reach all learners.

Another study by Stahl (1999) questioned the efficacy of using learning style theories in the classroom, particularly in the teaching of Mathematics. He carried out the study on the learning styles because of the teachers' failure to determine and consider learners' learning styles and matching them to instructional methods in their classrooms (Stahl, 1999). Furthermore, Stahl also questioned the whole validity of the learning style concept and cautioned that categorizing learners with resulting changes in teaching methodology could actually harm learners' achievement. That is considering learners' learning styles in teaching may have negative effects on the learners' performance. He further noted that learning is a fluid process that changes

over time as new skills are developed. Stahl (1999) recommended that teachers should accommodate those differences as they become evident.

Methods of identifying learners' learning styles

Jackson-Allen & Christenberry (2008) used the Learning Styles Inventory in the Dunn & Dunn (2006) model, and investigated the learning style differences between 25 low achieving African-American males and 25 high achieving African-American males in the tenth Grade at Clark Atlanta University. These researchers were particularly concerned with the learning modalities and motivational factors of the two groups. Their study indicated that more learning similarities than differences exist. No statistical differences in auditory, visual, or tactile modalities were found.

Matthews (1996) used the Kolb (1993) Learning Style Inventory and a learners' questionnaire that asked learners to rate their academic achievement. She collected data from nearly 6,000 high school learners throughout Southern Carolina. Her results showed that learners' learning styles had a significant effect on perceived academic achievement. Those learners whose styles favoured interpersonal relationships over deductive reasoning often rated themselves as academically "poor". On the contrary, the learners who showed an analytical preference in learning style rated themselves as being academically strong.

Riding & Caine (2000) correlated the learning styles of a group of 182 British Secondary School level learners to their achievement on the General Certificate of

Secondary Education (GCSE) examination. Believing that learning style characteristics could be simplified into two forms, Global/Analytic and Visual/Imagery, Riding, & Caine (2000) developed a learning style inventory to measure these dimensions and subsequently graphed the learners' performance on the GCSE examination. Riding, & Caine's (2000) research revealed that learners who were in the intermediate range on both learning style continuums performed best on the GCSE examination, and the two researchers theorized that these learners had the ability to "avoid the limitations of an extreme of style and can utilize the most appropriate facilities of both dimensions as the task requires" (p. 63).

Murray (2002) carried out a study on adult learners whose reading abilities were below a 6th Grade level. Murray administered the Kolb (1993) Learning Style inventory to the participants and discovered that these adult learners preferred a reflective observation learning style orientation. The least preferred learning style was abstract conceptualization. These adult learners were able to view situations from different perspectives and apply their experience to evaluate information. Murray's study also revealed that adults often have trouble in acquiring new information if the new information is not presented in a visual style. The incorporation of learning styles into the adult education classroom significantly improved the reading ability of the adult learners (Murray, 2002).

Most of the following studies (Murray, 2002; Matthews, 1996; Daniel et al., 2002) adopted the Kolb (1993) learning style inventory to determine the learners' learning styles. According to Yunyan (2004), versions of Kolb's learning style inventories

have been widely used as tools to help learners discover their own learning styles, to compare their strengths and weaknesses to the demands of the field into which they intend to move, and to stimulate their conscious efforts to develop new learning potentials. This study adopted the Kolb (2005) learning style inventory in order to identify individual learner's learning style.

Kolb (2005) Learning Style Inventory

Kolb developed the learning styles inventory from his Experiential Learning Theory model (Kolb, 1984) in which he had noted that learning was a dialectic process integrating experience and concept, observations, and action, which occur in all kinds of settings and encompass all life stages. According to Yunyan (2004) learning involves the integrated functioning of thinking, feeling, perceiving and behaving, as well as communications between the person and the environment. In order to maximise ones' own personal learning, each learner ought to understand his or her learning style and seek out opportunities to learn because learning styles are not fixed traits, but can change and adapt to different situations and learning contexts.

While educationalists (Garner, 2000; Coffield, Moseley, Hall, & Ecclestone, 2004; and Smith, 2010) questioned the validity and reliability of the learning styles inventory, the inventory also gained support from Honey & Mumford (2000); Entwistle & Walker (2000); Yunyan (2004) and McCarthy (2010) that there is a benefit in enabling learners to reflect on how they learn best and this is an important aspect of developing metacognition in young people. The supporters further noted that the inventory promotes greater interest in the subject material, enhances intrinsic

learning satisfaction, increases understanding, and retention of course material, develops the desire and ability to be continuous learners, improves communication, and interpersonal skills, problem solving, analytical thinking, and the critical thinking of learners. They also conclude that fostering metacognition is perhaps the most important advantage that can be claimed for applying learning styles theory to learning and teaching.

Entwistle & Walker (2000) and Yunyan (2004) state that the inventory has the potential to engage learners in topics of their interest, and that it provides opportunities to explore how those subjects can be applied to real-world situations. Yunyan (2004) further states that based on life experiences and innate characteristics, individuals may develop preferences for one or two particular phases of the learning process. Kolb (1984) emphasised that one needs to map an individual's location on concrete-abstract and active-reflective dimensions which makes it possible to identify the learners' relative emphasis of concreteness over abstractness and active experimentation over reflection. Learners can thus be classified into one of the four Kolb's learning styles, namely; converging, diverging, assimilating, and accommodating.

Assimilating learning style learners

Assimilating learning style learners are best at understanding a wide range of information and organizing it into concise and logical form (Honey & Mumford, 2000; Kolb, 1984 and Kolb & Kolb, 2001). They further state that assimilating learners are good at assimilating disparate facts into coherent theories, yet often not

interested in deducing hypothesis from the theory. Their strength lies in inductive reasoning and the ability to create theoretical models, in organizing disparate observations into an integrated explanation. They are interested in abstract ideas and concepts rather than people. They value the logical soundness of a theory more than its practical value. Kolb & Kolb (2001) further stated that their characteristic question should be 'What' and for these learners to learn better, the teacher should function as an expert.

Converging learning style learners

According to Kolb (1984), converging learning style learners are best at finding solutions to practical task by relating it to theories and ideas learnt. This type of learners is good at solving problems and making decisions and they also tend to do best in situations where there is a single correct answer to a question. Mathews (1996) and Murray (2002) state that converging learners organize knowledge by hypothetical-deductive reasoning and focused on specific problems. These types of learners are usually reluctant to express their emotion and prefer dealing with technical tasks than with social and interpersonal issues (Kolb, 1993), and therefore, their characteristic question is 'how'. To be effective, the teacher should function as coach, providing guided practice and feedback in the content being taught.

Diverging learning style learners

Kolb (1993) and Kolb & Kolb (2001)) state that diverging learners are best at viewing concrete situations from different points of view and organizing many relationships into a meaningful whole picture. They prefer brainstorming situations

to taking action. They are interested in people and tend to be imaginative and feeling-oriented. Daniel et al., (2002) noted that this type of learners involve themselves in new experiences, tackling problems by brainstorming and enjoy moving from one task to the next as the excitement fades and are especially good at imaginative ability and awareness of meaning and values. These learners' characteristic question of interest is 'why' and for them to learn better, the teacher should work as a motivator.

Accommodating learning style learners

Accommodating learners learn primarily from "hands-on" experience (Kolb, 1984; 1993). They prefer to act on feelings rather than on logical analysis. In solving problems, they rely more heavily on people for information than on their own technical analysis. Their strength lies in doing things, in carrying out plans and tasks and getting involved in new experiences. They are good at opportunity seeking, risk taking, and handling changing immediate circumstances. When the theory or plans do not fit the facts, they would discard the plan or theory.

Furthermore, Mathews (1996) and Yunyan (2004) stated that accommodating learners' characteristic question is 'what if', and for the lesson to be effective, the teacher should pose open-ended questions and then get out of the way, maximising opportunities for the learners to discover things for themselves. According to Kolb (1984), learning styles result from unique individual programming of the basic but flexible structure of human learning. The particular learning style is continuously shaped by a learner's personality disposition, his educational experiences, his

professional academic career commitment, the demand of his current job and the specific task he is working on.

Therefore, Yunyan (2004) stressed the need to consider learning styles in classroom environments. This provides teachers with a perspective to address conflicts between their teaching style and a learner's contrasting learning style by supplementing their instruction with aspects of other methods. Thus, teachers need to know that the quality of teachers and teaching in Southern Africa makes teaching that incorporates all learning styles very difficult.

Extent to which teachers can plan the lesson based on the learners' learning styles

Heimlich & Norland (2002) noted the discrepancy between teacher's knowledge of learning styles and teacher's application of this knowledge. Heimlich & Norland proposed that teachers should consciously adapt the role of "lifelong learners" and continue to study their own teaching methods to examine if they are effectively adapting information about learners' learning styles into their classroom practice. Drawing on the conclusions of Brown (2003), teachers might change their teaching styles through effective training, thus better meeting the changing demands of learner-centred learning.

According to Beihler & Snowman (2000), there are a number of things a teacher can incorporate into the lesson plan to accommodate different types of learning styles. The teacher can use the following standard academic method of instruction, lecture,

and reading, covering the aural and verbal activities. Furthermore, the teacher may use small group discussions, brainstorming sessions for diverging learning style learners and may use PowerPoint presentations, overhead projectors, even drawing on the chalkboard for visual (assimilating) learners. In-class exercises, tactile (converging) learners can be reached by being given independent research problems, and programmed outlines to fill in as the teacher lectures.

Claxton & Murrell (2004) believe that matching learners' and teachers' learning styles are most important when working with the underachieving learners. Some intentional mismatching may, however, be beneficial if handled sensitively, but care must be taken to ensure that the underachieving learner does not experience discontinuity. The above statements support the views of Smith, Sekar, & Townsend (2002) that most learners learn best when matched with teachers whose styles mimic their own.

Woolfolk (2007) states that before the teachers' accommodate all their learners' learning styles, they should remember that learners, especially young ones, may not be the best judges of how they should learn. Sometimes, learners, particularly those who have difficulty in learning, may prefer what is easy and comfortable while real learning can be hard and uncomfortable. Sometimes, learners prefer to learn in a certain way because they have no alternative; it is the only way they know how to approach the task. These learners may benefit from developing new and perhaps more effective ways of learning.

Wilson (2002) in reviewing the literature on learning styles concluded that, awareness of learning styles and skill in utilization of instructional methods will give teachers a wide array of techniques to use in promoting learner learning. Incorporating learning style theories into classroom practice motivates learners to invest time and effort in their academic achievement, leading to a feeling that school is a valuable resource for their lives, and decide to give education undivided attention (Woolfolk, 2007).

Cardellini & Felder (2004) suggested a balance between all learning styles as the key to accommodate diverse learning styles in the teaching and learning process. That is, to make sure that teachers address most of the learning dimensions rather than favouring one side at the expense of the others (Cardellini & Felder, 2004), and hence suggested that a balanced teaching approach should accommodate each stage of the learning process. On the same note, Ron (1999) states that, the teachers find it challenging to provide a balance for all types of learning styles during lesson presentation. This happens perhaps because of limited time for covering the syllabus, lack of teaching aids and uniqueness of every learner in the classroom. If the teachers give the balance to all learning styles, it might improve learners' performance.

Summary

The studies cited so far were conducted outside Namibia and the results are not conclusive as to whether matching teachers' and learners' teaching and learning styles will have positive effects on the learners' achievement in school subjects. It is against this background that this study was conducted to address the Namibian

context by investigating the effects of learning styles on the Grade 11 learners' performance in Mathematics at one Senior Secondary School in the Oshana Education Region. The next chapter presents the methodology of the study.

CHAPTER 3: METHODOLOGY

This chapter discusses the methodology used in this study. It discusses the research design and how the research site and study participants were selected. It further explains the instruments and methods used in collecting data from the sample. The data analysis procedures and research ethics are also discussed in this chapter.

Research design

The study was both of a qualitative and quantitative nature. According to Gay, Mills, & Airasian (2009) quantitative research is the collection and analysis of numerical data to describe, explain, predict, or control phenomena of interest. This study used an experimental design. Two classes of the Grade 11 learners were randomly selected and placed into the learning styles groups based on their learning styles.

Gay, Mills, & Airasian (2009) define qualitative research as the collection, analysis, and interpretation of comprehensive narrative and visual (non-numerical) data to gain insight into a particular phenomenon of interest. Macqueen, Namey, & Woodsong (2005) view the qualitative methodology as seeking to understand a research question from the perspective of those being studied and not from the researcher' perspective. This study was also qualitative in nature because a narrative design was used to gather information from the Mathematics teachers on how they identified learners' learning styles. According to Gay, Mills, & Airasian (2009), a narrative design is a study of how different humans experience the world around

them. The participants were expected to give the narrative of the behaviour being investigated based on their experiences.

Population

The population for this study was all the Grade 11 learners doing Namibia Senior Secondary Certificate (NSSC) Mathematics at Ordinary Level, and the Mathematics teachers at one Senior Secondary School in the Oshana Education Region. There were six (6) Grade 11 classes at the Senior Secondary School studied. Each Grade 11 had 32 learners. This gave a total of 192 learners. There were only three Mathematics teachers at the school and they were all included in the population.

Sample and Sampling procedures

Sixty-three (63) Grade 11 learners formed the sample from the population and three Mathematics teachers at one Senior Secondary School in the Oshana Education Region. The researcher used simple random sampling procedure to select the sample of 2 classes (63) learners for this study from the population. Each individual class (A, B, C, D, E and F) was written on a separate slip of paper and put in a box. Two classes were picked from the six Grade 11 classes. There were only three Mathematics teachers in the school, therefore, all the three teachers were asked to take part in the study.

Research instruments

Structured Interviews

Structured interviews were used to gather information from the Mathematics teachers. Bahta (2003) describes interviews as a group of methods that permit a researcher to engage in a conversation with the participants. In this study, the researcher used the structured interviews because she wanted to understand the reality that teachers construct. The researcher also used interviews, in order to get information that could not be observed directly such as the way the participants organised the world and the meaning they attached to things happening in the world (Bahta, 2003).

Litchtman (2006) stated that interviews are useful in the situations where the researcher is unable to observe the participants' behaviours, feelings, past events and future expectations. As such, the interview was seen to be ideal for collecting information from the Mathematics teachers to see the extent to which they planned their lessons based on the learners' learning styles.

Kolb's Learning Style Inventory

Kolb's (2005) Learning Style Inventory was used in this study for identifying learners' learning styles. The inventory consists of 32 questions about the way in which one learns. The learning inventory was given to the learners to complete. Each learning style had 8 items which were associated with an individual in terms of best fit on the scale of 1- 5 (Strongly agree, Agree, Not Sure, Disagree and Strongly

disagree). The learners were asked to complete the inventory by ticking every option based on the level of agreement. The scores were added together for each learning style for each learner. The learners were placed in a learning style in which they had scored the high points and thus the learners were placed in four learning styles groups diverging, converging, assimilating and accommodating.

Pre-test and Post-test on Algebra

A pre-test and post-test on Algebra topics (see Appendices G and I) were designed to find out whether there was a significant difference in the performance of learners in Mathematics and their learning styles. Learners were tested on Algebra because it is one topic they mostly find difficult to understand and is integrated in almost all Grade 11 and 12 Mathematics topics.

Data collection procedures

The researcher obtained permission from the Permanent Secretary and then notified and asked the Oshana regional office for permission to carry out the study at one Senior Secondary School. After getting the permission from the Permanent Secretary and regional office, the researcher delivered the letter to the principal of the school in order to carry out her study.

All the selected learners were given pseudo names which they used during the data collection process. In the first week of this study, all the selected learners were placed in the four learning style groups using Kolb's (2005) Learning Style Inventory. Kolb's (2005) Learning Style Inventory revealed that 15 learners were

diverging, 16 were converging, 17 were assimilating and 15 were accommodating learning style learners. After the learners were placed in their learning style groups, the four groups wrote the pre-test on Algebra which tested the learners' knowledge on Algebra. The researcher also finalised her teaching time table with four periods per day and each learning style group had one period per day. In the second week, the researcher taught Algebra to each learning style group using the preferable teaching methods for each learning style group as stated in Kolb' (2005) Learning Styles Inventory. The teaching phase took three weeks and the learning style groups wrote the post-test in the forth week. The Mathematics teachers were interviewed during their free times to avoid interfering with their normal school work. The interview was done for three days, one teacher per day. The Mathematics teachers' responses were recorded and interpreted.

Lessons taught to the learners with different learning styles

The four groups with different learning styles were taught Algebra topics separately. The lessons were planned and taught using the learning objectives and competences in the syllabus. The researcher prepared only one lesson plan per day and used different teaching methods for each learning style group. The researcher tried to teach according to the envisaged effective approaches and might not have developed the best lesson, but, she considered the learner-centred approach by making sure that the starting point of each lesson had included the learners' existing knowledge and linked the lesson to learners' experiences. Considering learners' pre-knowledge may have helped learners to arouse their interests, and to investigate further and make

sense of the new concepts learnt (Njenga, 2010). The problems about substitution and solve for unknowns were contextualised particularly for the diverging learning style learners whose characteristic question is 'why'.

Furthermore, the researcher explained the main purpose of the study to the selected learners for the study and encouraged them to participate in the lessons. The researcher then gave the participants the general introduction to the topic and gave each participant a hand out with the list of learning objectives and learning competencies as prescribed in the Grade 11-12 Mathematics syllabus. The learning objectives informed the participants on what they should prepare and what they were expected to learn during the lessons.

Each lesson was 40 minutes long. For the first five minutes of each lesson, the researcher asked the entire group how to solve a certain problem. The assimilating and converging learning style learners gave the solution to the researcher without consulting other learners while, the diverging and the accommodating learning style learners first discussed with each other before giving the solution to the researcher. The researcher used jigsaw teaching method for accommodating learning style learners, think-pair-share teaching method for diverging learners, lecture teaching method for assimilating learning style learners and demonstration teaching method to teach the converging learners.

Jigsaw teaching method

The researcher used a jigsaw method to teach the accommodating learning style learners because these learners use other learners' analysis to learn new concepts.

This approach ensured that every learner participated in the discussions of the group. Aronson, Fried, & Good (2002) described the jigsaw method as a cooperative learning approach where each member of the small group is given a problem to solve for a certain amount of time and then later the members give each other opportunities to show how they solved the problem.

In using the jigsaw method, the researcher gave out Mathematics problems to five groups, each group had 3 learners. Each group discussed and presented their group solution to the entire class. During the group presentations, the researcher posed the 'what if' questions in order for every learner in the class to get the opportunity to carry out their own analysis. This approach gave room to the entire class to hear and critique different methods of solving a given problem. For example, solve quadratic equations methods such as factorisation, completing the square and using the formula (see Appendix J).

Think-pair-share teaching method

The researcher used a think-pair-share method to teach the diverging learners because these learners learn better in situations that require the generation of ideas and gathering of information from other learners. By using a think-pair-share strategy, the researcher gave the question to the whole group of 15 learners. The learners were then given five minutes to work out solutions and then paired with partners to compare and discuss their solutions. The researcher motivated each pair to share their ideas with the whole group. The learners in think-pair-share strategy sat in groups of four with two members in each group facing each other.

According to Njenga (2010), the think-pair-share approach provides opportunities to learners to learn higher-level thinking skills from their peers, raises self-esteem and accommodates everyone in the class. Njenga (2010) further stated that a learner is more comfortable presenting refined ideas to the group with the support of a partner. The diverging learning style groups were arranged differently everyday in order to give the chances to the learners to work and think with different partners. The pair discussions were monitored by the researcher and common misconceptions as well as unique ideas were discussed with the whole group.

For example, the researcher posed a problem to the learners about changing the subject of a formula. She allowed the learners some time to think individually and that gave them a chance to struggle with the problem and began to make their own answers. Then, she allowed the learners to discuss the problem with a partner ("pair"). During the discussion the learners construct their own knowledge, questioned their understandings, and found out what they knew and what they did not know.

Lecture method

Jacobs, Vakalisa, & Gawe (2011) defined lecture method as an oral presentation intended to present information or teach learners about a particular subject. Jacobs, Vakalisa, & Gawe further stated that the lecture method makes it easy for the teacher to control the material to be used and keep the class focused on what is important.

Therefore, researcher used the lecture method to teach assimilating learning style learners because these learners require a good clear explanation from the teacher rather than other learners.

According to Kolb (1993) this type of learners do not need a hands-on strategy because they do not like practical work. The researcher always explained the steps involved in solving a particular problem and then gave individual activities. For example, solving word equations, the researcher gave the list of words in English and translated them into Mathematics language (see Appendix K) e.g., difference means subtract, product means multiple and quotient means divide.

The researcher checked the learners' work and gave the feedback by explaining why a certain answer was considered incorrect. For example, when the question asked the learners to triple but some learners doubled, and then the answer for those learners who doubled was wrong. The researcher also gave the learners the opportunity to reflect on their work and chose a better procedure to solve the problem. This enables the teacher to anticipate the learners' concerns or questions and prepares to go into more detail about topics that may be confusing or more difficult to understand, while glossing over topics that are easy to grasp.

Demonstration method

The researcher used the demonstration method to teach the converging learners. During the period, the researcher allowed the learners to repeat the steps in a 'hands

on' practical session to reinforce the learning process. Furthermore, the researcher also walked around the classroom and checked how the learners were progressing. She also corrected the learners' mistakes, and reinforced proper steps that helped them learn the task more quickly.

For example, addition and subtraction of algebraic fractions, the researcher explained and demonstrated to the group: If there is more than one term on top of the fraction put brackets, next, make the denominators the same by getting the Lowest Common Multiple and then, simplify the top (numerator). The researcher gave the class an activity, checked the learners' work, repeated the steps involved on the chalk-board once again, and then asked the learners who did not get the correct answer to follow the steps and redo the activity.

According to Jacobs,Vakalisa, & Gawe (2011) the demonstration step gives the learners the opportunity to see and hear the details related to the skill being taught. This method also allowed the learners to learn by trail-and-error to solve the problems. Repetition step helps the average learners and slow learners the additional opportunity to see and hear the skill being taught (Jacobs,Vakalisa, & Gawe, 2011).

The teaching sessions ran for three weeks. The Mathematics post-test was written immediately after the teaching had ended. All 63 learners who participated in this study wrote the post-test at the same time and in the same room. This minimised the external influences on the performance of the learners by allowing them to write under the same environmental conditions. Four teachers at the school where the

study was conducted invigilated the Mathematics pre-test and post-test. The test scripts were collected and later marked by the researcher.

Pilot study

The structured interviews (see Appendix E) with teachers and Kolb's (2005) Learning Style Inventory for the learners were piloted at one Secondary School in the Oshikoto Education Region other than the selected school for the main study. The learners in the pilot study were from similar background as the learners of the Secondary School where the main study was carried out. Pilot testing was done before the researcher embarked upon the collection of the data. All the instruments (Kolb learning style inventory, pre-test and post-test and structured interviews) were piloted and provided information about the deficiency of the instruments. Pre-test question 6 (c) Factorise $bx + by + ax + ax$ was rectified to: Factorise $bx + by + ax + ay$.

Upon the end of the interviews with the three Mathematics teachers at the secondary school in Oshikoto Education Region, it was found that not all the questions were appropriately and sufficiently answered. According to Meriwether (2001) a pilot study greatly reduces the number of unanticipated problems because one has an opportunity to redesign parts of their study to overcome difficulties that the pilot study reveals. This helped the researcher to restructure the interview questions (see Appendix E) for collecting the main data from the Mathematics teachers at the selected secondary school in the Oshana Education Region for this study. The researcher also corrected the typing errors spotted by the Mathematics teachers. The

data collected from the pilot study were used to estimate the reliability and validity of the instruments.

Data analysis

The data collected from the structured interviews were analyzed by means of interpretive analysis. According to Blanche, Durrheim, & Kelly (2006) interpretive analysis provides a 'thick description' of the characteristics, processes, and contexts that constitute the phenomenon being studied. This was done by identifying themes that emerged from the literature and from the data collection (Gay et al., 2009). The following procedures were used in the interpretation of data from the individual structured interviews: quantifying qualitative data, comparing results and consolidating the data.

The responses from the learning styles group tests (pre-test and post-test) were placed in a frequency table for comparisons and for further analysis. Furthermore, Analysis of Variance (ANOVA) was used to determine whether scores from the learning styles groups were significantly different at a probability level of $\alpha = 0.01$.

Ethical considerations

The participants were briefed on the objectives of the research, and the benefits accruing from participating in the study before the interview was conducted with the three Mathematics teachers and before the questionnaires were given to the learners. The participants were also told that the information will be kept strictly confidential by using pseudo names. The researcher behaved in an honest manner in order for the

participants to behave in the same way (Gay et al., 2009). The participants were also told that they had the right to withdraw at any time it they so wished because participation in this study was voluntary.

Summary

The study was both qualitative and quantitative in nature. Two classes of the Grade 11 learners were randomly selected and placed into four learning styles groups using Kolb's (2005) Learning Style Inventory. The pre-test and post-test were used to find out if there was a significant difference in the performance of learners in Mathematics and their learning styles. The research also used structural interviews to collect data from the Mathematics teachers. Each learning style group was taught in a separate classroom because their lessons were structured differently. The study was piloted at one secondary school in the Oshikoto Education Region. Interpretive analysis was used to analyse the qualitative data and Analysis of Variance was used to analyse the quantitative data.

CHAPTER 4: PRESENTATION AND DISCUSSION OF RESULTS

This chapter presents and discusses the data that were obtained in this study. The study sought to determine the effects of learning styles on the performance of the Grade 11 Mathematics learners in the Oshana education region. The chapter is divided into five sections namely: participants' biographies, learning styles, effects of learning styles on learners' performance in Mathematics, methods used by Mathematics teachers to identity learners' learning styles and the extent to which Mathematics teachers plan their lessons using the learners' learning styles.

Biographical information of the participants

The study had 63 learners (30 males and 33 females). Their ages ranged from 15 to 20 years. These learners were divided into four learning styles groups: the accommodating, assimilating, diverging and converging groups. The learners who participated in this study were from similar backgrounds, they were all doing Mathematics at Ordinary Level Grade 11-12. Three Mathematics teachers (one female with a Master degree and two males, one was a Bachelor degree holder and another was a Basic Education Teachers Diploma holder) formed part of the sample also.

Learning styles utilised by Grade 11 learners to study Mathematics

In this study the learners were given the Kolb's (2005) Learning Styles Inventory to complete. The inventory revealed (see Appendix F) that 15 learners were the diverging, 16 learners were the converging, 17 were the assimilating and 15 were the accommodating learning style learners. The learners were placed in four learning

style groups; accommodating, assimilating, diverging and converging. All the information collected in this study was based on the four Kolb's (2005) learning styles.

The effects of learning styles on Grade 11 learners' performance in Mathematics

The effects of learning styles on the learners' performance were determined by comparing the Mathematics pre-test and post-test results. These results were analysed using descriptive statistics by calculating the mean, median and the standard deviation of each group as shown in Table 1.

Table 1: **Descriptive Statistics of learners' performance in Mathematics pre-test in Learning Style Groups.**

Learning style	**Number of learners**	**Pre-test**		
		Mean	**Median**	**STD**
Diverging	15	12.1	12	1.87
Converging	16	12.1	12.5	1.76
Accommodating	15	11.9	12	2.55
Assimilating	17	12	12	3.49

The mean score of all the four groups were almost the same in the pre-test and ranged from 11.9 to 12.1. The researcher has been teaching Mathematics at secondary school level for 9 years and this experience enabled her to teach the four learning styles groups the Algebra topics for three weeks. Each learning style group

was taught using the appropriate method of learning Mathematics. In most cases the researcher posed the questions in the form of scenarios to the whole learning style group. Each learning style group reacted in the way it learns best. The diverging and the accommodating learners always consulted others to make sure that their answers were correct before giving the answer to the researcher. While the converging and assimilating learners gave their answers without consulting others.

Furthermore, the converging learners were interested in knowing how a certain problem was solved and wanted to be given more exercise to practice. The researcher functioned as the couch, gave practical guidance and feedback using demonstration method when working with converging learning style learners. These learners worked on their activities individually. The diverging learners were interested in knowing why a particular problem was solved in a given manner using certain steps. The researcher motivated the learners to solve the problems using the method that they knew as long as they got the correct answer and showed their work clearly.

According to Kolb (1993) the accommodating learners like to carry out plans, tasks and get involved in the new experiences. For this group, the researcher posed the open-ended questions in almost all 14 lessons in order for all the learners to make their own analysis of the questions. The learners did group work activities in order to listen to other learners' ideas and make the final conclusion. The researcher acted as an expert when she was working with the assimilating learners because these learners tend to ask the question 'what'? During the lessons presentation, the researcher

explained all the steps involved in solving the given problem and then gave individual activities.

After the intervention, all the learners in the four learning styles groups wrote the Mathematics post-test. The post-test results showed that, the converging learning style learners performed better than other learning styles groups (see Table 2).

Table 2: **Descriptive Statistics of learners' performance in Mathematics post-test in Learning Style Groups.**

Learning style	**Number of learners**	**Post-test**		
		Mean	**Median**	**STD**
Diverging	15	15.2	15	2.76
Converging	16	17.7	18	2.75
Accommodating	15	16.4	16	3.75
Assimilating	17	15.6	16	3.38

The results in Table 2 show the mean score of 17.7 for converging learners was greater than the mean score for all other three learning styles groups. Sharp (2001) carried out a study using the lecture (traditional) and teaching around the table (holistic) instruction to teach the diverging, the converging, the assimilating and the accommodating learning style learners. She indicated that converging and accommodating learners were likely to get lower scores than the more assimilating and diverging learners when teaching was traditional. The results of this study and those by Sharp (2001) showed that the converging and accommodating learning style

learners obtained high marks when their preferred learning styles were considered during the intervention.

Onwuegbuzie (2001) states that learners who prefer to learn in co-operative learning groups tend to obtain lower scores in their courses in which all assignments are carried out and graded individually than do their counterparts who have more individualistic orientations. According to Kolb (2005) learners with a converging, and accommodating learning style like to apply the ideas to the world around them and see what would be the results. The researcher gave the converging and accommodating learning style learners the opportunity to practice. These learners also found out where do the exercises done in the classrooms can be applied in everyday life, e.g., substitution can be used in currency exchange. The teaching styles used to teach the converging and accommodating learners could also be the one contributed to high performance of these learners in Mathematics.

The results in Table 2 also show that the learners' scores spread out from their mean scores. The scores of the "assimilators" were spread out more (3.49) from their mean in the pre-test and 3.38 from the mean on the post-test. The standard deviations for the assimilating learning style learners in Mathematics pre-test and post-test were almost the same. This indicated that the spreading out of learners' scores from their mean score was almost the same in both pre-test and post-test because both tests varied almost the same.

The quantitative data were analyzed using the Analysis of Variation (ANOVA) at the 0.01 level of significance to test the null hypothesis: there is no significant difference

in the performance of the Grade 11 learners in Mathematics and their learning styles. The results are shown in Table 3.

Table 3: The ANOVA summary for the pre-test results

Sources of variation	**Sum of squares**	**Df**	**Means square**	**F-ratio**
Between groups	7.218	3	2.406	0.500
Within groups	283.76	59	4.809	
Total	290.978	62		

The Fischer ratio was found to be equal to 0.500 and $F_{critical}$ at significant level 0.01 was 4.31 with 59 degrees of freedom. Therefore, it could be concluded that there was no significant difference between the learners' performance and their learning styles in the pre-test. The four groups' performance on the pre-test was about the same.

The researcher then taught each learning style group the Algebra topics and all the learners in each learning style group were post-tested. The ANOVA for the post-test results are given in Table 4.

Table 4: The ANOVA summary for the post-test results

Sources of variation	**Sum of squares**	**Df**	**Mean square**	**F-ratio**
Between groups	228.85	3	76.282	12.79
Within groups	351.87	59	5.964	
Total	580.72	62		

The ANOVA results of the post-test in Table 4 show the Fischer ratio equal to 12.79 and $F_{critical}$ was 4.31 at significance level 0.01 and 59 degrees of freedom. This showed $F_{critical} < F_{calculated}$ and thus the null hypothesis was rejected (i.e. there was a significant difference in the learners' performance in Mathematics and their learning styles). Furthermore, the Scheffe test was carried out with the aim of finding out which pairs of means were significantly different at the 0.01 significance level. Six pairs of means were compared and the results are presented in Table 5.

Table 5: The comparisons of pairs of means in the post-test

Mean	**Scheffe test**	**Pair of mean being Compared**	**Conclusion**
$\bar{x}_1$=15.2 & $\bar{x}_2$=17.7	F_1= 6.704	Diverging and Converging ($F_1 > F_{crit,}$)	There was a significant difference in the Diverging and Converging learners' performances.
$\bar{x}_2$=17.7 & $\bar{x}_3$=15.6	F_2= 5.036	Converging and Assimilating ($F_2 > F_{crit}$)	There was a significant difference in the Converging and Assimilating learners' performances.
$\bar{x}_3$=15.6 & $\bar{x}_1$=15.2	F_3= 0.177	Assimilating and Diverging ($F_3 < F_{crit}$)	There was no significant difference in the Assimilating and Diverging learners' performance.
$\bar{x}_4$=16.4 & $\bar{x}_1$=15.2	F_4= 1.496	Accommodating and Diverging ($F_4 < F_{crit}$)	There was no significant difference in the Accommodating and Diverging learners' performance.
$\bar{x}_4$=16.4 & $\bar{x}_2$=17.7	F_5= 1.813	Accommodating and Converging ($F_5 < F_{crit}$)	There was no significant difference in the Accommodating and Converging learners' performances.
$\bar{x}_4$=16.4 & $\bar{x}_3$=15.6	F_6 = 0.707	Accommodating and Assimilating ($F_6 < F_{crit}$)	There was no significant difference in the Accommodating and Assimilating learners' performance.

The means shown in Table 5, i.e. $\bar{x}_1$ was the mean for diverging learners, $\bar{x}_2$ was the mean for converging, $\bar{x}_3$ was the mean for assimilating and $\bar{x}_4$ was the mean for accommodating learners.

The results in Table 5 show that there was a significant difference between the diverging and converging learners' performance. There was also a significant difference between the assimilating and converging learners' performance. The Scheffe Test ratios for the two pairs (F_1= 6.704 and F_2 = 5.036) were greater than the $F_{critical}$ = 4.31 at significance level 0.01 with 59 degrees of freedom. However, the other Scheffe Test ratios F_3, F_4, F_5 and F_6 were less that $F_{critical.}$ This implies that there was no significant difference between the four pairs of means. Hence, the four pairs were almost the same in terms of performance even though they learn differently.

Interviews with the Mathematics teachers

The researcher explained to the three Mathematics teachers what learning styles were. She then asked the three Mathematics teachers (Teacher A, Teacher B and Teacher C) to explain the types of learning styles their learners used in learning Mathematics. The teachers mentioned that they use different learning styles in their classrooms. All the three stated '*some of the learners preferred to watch pictures or demonstrations*', and in this study these learners were classified as assimilating learning style learners. The three teachers also stated '*some learners preferred to listen to the teachers' explanations*' and in this study these learners were classified as diverging learning style learners.

The three Mathematics teachers further stated '*some learners preferred to do experiments and practical activities when studying Mathematics*.' These learners were classified as converging learning style learners and some were the accommodating learning style learners. The learning styles mentioned by the three Mathematics teachers matched well with the Kolb (2005) learning styles which are diverging, assimilating, accommodating and converging.

The Mathematics teachers further gave detailed explanations of how each group of learners was different from the other.

Teacher A: *Assimilating learning style learners learn best through visual aids which includes facial expressions and body motions of the teachers, pictures and texts with illustrations. These 'assimilating learning style' types of learners think and learn best by imaging pictures.*

Teacher A's explanation supports Dunn & Dunn (2006), and Kolb (2005) learning styles which are visual and assimilating learning styles. Dunn & Dunn and Kolb further say that the learners with visual or assimilating learning style prefer to use images, pictures, colours, and maps to organize information and communicate with others. Therefore, these learners can easily visualize objects, plans and outcomes in their mind's eye.

Teacher B: *some learners learn best by hearing what they want to learn*.

This implies that some learners preferred to listen to discussions, listen to the teachers when highlighting the lesson's main points, talking matters over to

themselves and reading out the texts. According to Kolb (2005) these learners fall in the group of diverging learning style learners.

T**eacher C**: *Learners who learn best by moving and doing prefer interactive learning, learning through practical challenges and hands on experience.*

This implies that some learners learn with their eyes or with their ears and some prefer to learn by experience or by hands-on tasks and according to Kolb (2005) these learners have the accommodating learning style.

Teacher C further stated '*Some learners might also need note books to write down points they think are important from what they read, hear or see*. *These types of learners are likely to grasp information as they move from one place to another'.*

In this study these learners were the converging learning style learners. The learning styles indicated by the Mathematics teachers as being used by their learners to study Mathematics were also similar to the general learning styles outlined by Hamacheck (1995) which are visual (reading), aural (listening), and kinesthetic (actively doing things).

The kinesthetic (actively doing things) learning style matched the converging (think and do) and accommodating (feel and do), the visual (read/write) matched with assimilating (think and watch) and the auditory (aural) matched with diverging (feel and watch) in this study. Kolb (1984) states that individuals tend to favour and develop one mode of grasping experience and one mode of transforming experience which eventually shapes each type of learning style.

Mathematics teachers' views on the effects of learning styles on the learners' performance in Mathematics

The Mathematics teachers were asked to state the perceived effects of the learning styles that they had indicated on the learners' performance in Mathematics. These are given in this section.

Teacher A: *The visual (assimilating) learning style learners found it easy to make recollection of information when they saw pictures similar to those through which they had learned information in a different environment from where they had learnt that information. On contrary, assimilating learning style learners had experienced difficulties when only texts and speeches were available for learning, without any visual aids*.

Teacher B: *Auditory (diverging) learning style helped learners to assimilate and retain information they had heard without having to see it in texts or pictures. However, these learners needed the silent environment for them to listen quietly*. *The assimilating learning style made the learners more self-dependent because they always take notes and with their own note taking, they can learn much better by themselves. However, these learners had experienced the difficulties of not being able to learn easily where the only medium of instruction was visual or audio, or where they were not access to writing materials because classroom atmosphere and teaching materials were always dictating the classroom presentation*.

Teacher C: *Accommodating and converging learning style learners had exposed to practice and evidence because these learners practiced and practiced what they*

learnt, and saw the evidence of what they had digested with difficulty from texts or discussions. However, this kind of learners were therefore not comfortable sitting in a place for long particularly if they was no practical work in that particular day.

These converging learners are likely to loose concentration in the lessons whenever no practical work was prepared for them to be busy. Teacher C continued further:

Teacher C: *Teaching the converging learners was a challenge to them because there were no enough classes at the school for every teacher to own a fixed classroom in order to allow learners to rotate from one classroom to another. Apart from that, there were no enough teaching aids to keep these learners busy all the times*.

According to the report by the University of Pennsylvania (2009) in the United States of America, kinesthetic (converging) learners learn best through a hands-on approach, actively exploring the physical world around them and like to apply course material in new situations to solve problems. In this study the researcher was in a fixed classroom and learners were the ones coming to the researcher's classroom. The researcher also used different teaching aids that kept the learners actively involved in the lessons, and this might have contributed to the better performance of the converging learners.

Yunyan (2004) argues that teachers should build different activities into lessons because it will be of real benefit to these learners, as is the structure of the three-part (touch, think and talk) lesson, which may overcome some of the problems associated with doing the same activity for long periods. The converging learners may find it hard to sit still for long periods and may become distracted by their need for activity

and exploration. Therefore, these kinds of learners should be given the opportunity to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows failing safely (Dunn & Dunn, 2006).

The Mathematics teachers were further asked to give their views on the perceived effects of the learning styles on the learners' performance in Mathematics in general. The Mathematics teachers indicated both positive and negative effects of learning styles on teaching and learning of Mathematics. These are indicated in this section. The Mathematics teachers indicated in this study that incorporating learners' learning styles in planning was very crucial in teaching and learning of Mathematics.

Teacher A: *it helped learners to absorb the content better particularly learners who had learning difficulties*.

Teacher C: *Learners became the active participants in the lesson and their communication skills were enhanced*.

Teacher B: *learning styles made the learners the self-governed learners where they acquired knowledge independently*.

The teachers' views seem to support those by Onwuegbuzie (2001) who stated that learning styles assisted learners to understand their own learning preference to learn the subjects and promote logical thinking skills.

Teacher C: *Most learners got the opportunity to manipulate the information to suit their need and had developed the insight into issues*.

Teacher A: *Knowing learners' learning styles gave teachers the opportunity to work with learners of different levels (slow, average and fast learners) during classroom interaction*.

What the Mathematics teachers indicated might help the learners to develop a sense of belonging, improve their self-esteem and might enhance their study skills. Knowing learners' learning styles might also give the Mathematics teachers the opportunity to know their learners better, help the learners with learning difficulties and prepare additional work for the fast learners (Murray, 2002; Onwuegbuzie, 2001).

The views of the Mathematics teachers on the effects of incorporating learning styles into classrooms on the learners' performance support Meriwether's (2001) views. He stated that learning styles helped some teachers to understand their learners' learning needs and helped remove barriers to their learners' learning potentials. Furthermore, the Mathematics teachers might identify the needs of 'slow', 'average' and 'gifted' learners and find a better method of accommodating these mixed abilities learners in the same lesson at the same time. According to Hamachek (1995) identifying learners' needs might make teaching and learning easy and smooth, and might also result in better academic performance and more learning satisfaction.

The Mathematics teachers also commented on the disadvantages of incorporating learning styles in the teaching and learning of Mathematics.

Teacher A: *Considering learners learning styles in their planning was time consuming because all learners had different learning styles. As a result, I had covered less content within a given time frame and we were working with curriculum driven system.*

Teacher B: *Incorporating learners' learning styles in the classroom instructions requires more time and I have a limited time for covering the syllabus.*

Teacher C: *Some learners were not comfortable with some of the learning styles particularly the learners who preferred to study alone had felt that they were not benefiting from group work activities. Some of the learners, who had known their own learning styles, had stopped from trying and experiencing other learning styles. These learners had resisted to change and only continued to utilise the learning style that they believed was best for learning Mathematics.*

It seems like the Mathematics teachers felt that incorporating learners' learning styles in their teaching required much time. Furthermore, the Mathematics teachers seemed to have a view that, incorporating learners' learning styles in planning and lessons presentations required attention because it might restrict some learners from getting to know other learners' learning styles or experience how other learners learn.

Dunn, Beaudry, & Klavas (2001) argue that learners may enjoy learning more when they are taught in a way that takes into account their learning style preferences. Dunn

et al. (2001) further stated that learners can easily label themselves as belonging to a specific learning style only. Thus, the teacher should help learners to identify their learning styles in different subjects because learning styles change with the times, the content, age as well as experience (Dunn et al., 2001). Finally, it can be said that for better teaching and learning to take place, teachers should try to match their teaching styles with their learners' learning styles.

The methods used by Mathematics teachers to identify learners' learning styles

The three Mathematics teachers were asked to state the methods they used in identifying their learners' learning styles.

Teacher A: *I used questionnaire with items to be chosen by the learners and the items were based on their level of agreement.*

Teacher C: *I used the Index of Learning Styles questionnaire developed by Felder and Solomon but I cannot remember the year. The model had gained popularity among the researchers on learning styles therefore I had chosen to use it.*

Teacher C also explained what the inventory assessed and how it was used. He stated that the questionnaire assessed the four model dimensions such as sensing/intuitive, visual/verbal, sequential/global and active/reflective. The questionnaire he used consisted of 44 items with possible answer choices and each dimension had 11 items. The difference between scores for two opposing dimensions (e.g active scores-reflective scores) determined the learners' preference along the particular dimension.

Felder & Spurlin (2005) concluded that learning styles reflect preferences and tendencies but not infallible indicators of strengths or weaknesses in either the preferred or the less preferred categories of a dimension. Felder & Spurlin further noted that the Index of Learning Styles has two principle applications which are: to provide guidance to instructors on the diversity of learning styles within their classes and to help them design instruction that addresses the learning needs of all their learners, and to give individual learners insights into their possible learning strengths and weaknesses.

Teacher C stated '*I exposed the learners to different learning styles, assessed the learners and recorded their performance as a tool to determine the learners' learning styles. The learning style in which a learner got the highest score is where that particular learner belonged to*. *Assessing learners learning styles was time consuming because it took me a two months to know each individual learner' learning style*'.

However, teacher B stated '*I used observation in identifying the learners' learning styles*'.

Teacher B seemed to use her own judgement on how learners learned Mathematics, which might not give a true reflection of how learners learn. Teacher A and teacher C used Kolb's (2005) Learning Style Inventory and Felder-Solomon's (2001) Index of Learning Styles as a tool to identify learners' learning styles. These two Mathematics teachers (teacher A and teacher C) seemed to have used the better methods of identifying learners' learning styles. The two inventories are used by many researchers to identify learners' learning styles world wide (Smoak, 2007).

The Mathematics teachers were also asked how their own learning styles helped them to identify their learners' learning styles.

Teacher B: *My own learning style became the first method to put to test*.

Teacher B: *I have different learning styles, depending on the time available for learning a particular concept, therefore, it became difficult for me to use my own learning style to identify my learners' learning styles.*

It is assumed that teacher B exposed learners to his own learning styles during teaching and assessed them. Learners who scored high marks from topics taught following the teacher's teaching style were assigned to that particular learning style. While teacher B did not have any specific learning style that helps him to identify the learners' learning styles.

Teacher C: *I learn better through practical activities and sharing ideas with others, therefore, I used the method through which I learn better to teach my learners*. That is how teacher C identified learners who liked practical work (converging and accommodating) sharing of ideas (diverging) and those who did not like practical work and the sharing of ideas (assimilating).

The Mathematics teachers were also asked to state the methods they used to teach Mathematics. Their responses included:

Teacher A: *I used discussion, individual work, questions and answers, project, role play*.

Teacher B: *I used individual work, group work, talk and chalk board.*

Teacher C: *I used games, peer teaching, problem solving and experimental method and sometimes, I asked learners to solve practical problem or real life based problem and use concrete materials. I gave real life based problems occasional because of lack of teaching aids and hence because not all topics were able to be related to real life situations in Mathematics*. Giving the learners the real-life based problems to solve helped learners to contextualise the content taught in the classroom.

Teacher C further stated that '*I did not only teach learners how to accumulate facts, skills and knowledge but also taught them how to become the responsible and democratic adults in future through solving real life based problems'.*

According to Geonnotti (2008), learners' organisation schemas become less egocentric and begin to incorporate knowledge gained from experience into their thought processes. The Grade 11 learners who participated in this study were between 15 and 20 years old, and according to Geonnote these learners were able to use their pre-knowledge for new learning. Some of these learners were also in the adolescence stage and there is a need for them to be prepared well for adult stage.

Furthermore, basing Mathematics practical problems on real life situation had been supported by Fredenthal (1991) who stated that Mathematics has to be connected to reality, close to children and be relevant to society in order to be of human value. Fredenthal further stated that realistic approach to Mathematics teaching gives

learners the opportunity to develop their reasoning through exposure to real-life or contextual problems. Fredenthal's realistic approach to Mathematics supports teacher C's teaching methods of asking the learners to solve practical problems which are based on real life situations. Moreover, it seemed like all the three Mathematics teachers only facilitated the process and helped learners to seek solutions and to solve problems on their own in most cases.

Jacobs, Vakalisa, & Gawe (2011) stated that little time if any, needs to be given to the learners to experiment with a variety of activities in order to achieve what they are expected to understand. The use of different teaching methods leads to the productive interaction between the teacher and the learners and among learners (Jacobs et al., 2011). Through this process, learners might say what they found confusing and teachers might enhance the accommodation of different learners' learning styles by using different teaching methods.

Therefore, Mathematics teachers should make sure that they develop meaningful activities that stimulate learners' desire to solve Mathematics problems that will help them to think systematically and be able to hypothesize. One of the rationales for the Grade 11 and 12 Mathematics Syllabus is to prepare learners to function effectively in the 21st century by providing a basis to use Mathematics in their personal and professional lives (NIED, 2009). The emphasis is for the Mathematics teachers to provide learners with ample opportunities for learning and for doing something observable.

The extent to which Mathematics teachers plan their lessons based on the learners' learning styles.

The Mathematics teachers were further asked how they made sure that their lesson plans were based on the learners' learning styles. The following were their responses:

Teacher A: *I did not stick to the lesson plan if my learners did not understand the lesson taught.*

Teacher B: *I made sure that my lesson plans were flexible and inclusive*.

Teacher C: *I can change my teaching methods based on my learners' participation during the lesson presentation in order to accommodate all learners in the classroom.*

Chapman (2006) expressed the need for flexibility when he cautioned the beginner teachers that, as soon as the teachers present their lesson they are confronted with the different situations that require the proper interaction between the learners and the teachers. Mathematics teachers need to plan their lessons in advance and select the appropriate teaching strategies for executing them. Therefore, lesson presentation should be seen as a frame of reference in guiding learners' learning activities.

Furthermore, Chapman (2006) stated that teachers should not merely view the lesson preparation process as a rigid step-by-step procedure that must be followed in a fixed time but should be flexible depending on the present situation dictating in the classroom. It might be better for the Mathematics teachers to encourage learners to

consult a variety of resources so that the learners can learn that the teacher is not the only source of knowledge. Through this, the learners might end up asking their Mathematics teachers to give them challenging work that requires them to explore and investigate more information and become independent learner.

The Mathematics teachers were also asked to indicate how their teaching styles helped them to plan lessons based on their learners' learning styles. Their responses are indicated here.

Teachers A: *I had provided the lesson plan structure to a class or made the lesson more informal, depending on what was required for that particular lesson*.

Teachers B: *I considered various learners in their classrooms and their primary mode of learning and use this in preparing the lessons. I also try to maintain a very informal atmosphere and used different teaching methods and tactics that had made my lessons fun by including a lot of jumping around that had kept the interest of the learners*.

Teachers C: *I find out what learners enjoy, understand and what learners find challenging in order to plan their lessons*.

Jacobs, Vakalisa, & Gawe (2011) stated that an indirect teaching (non- lecturing method) style can be used by the teachers when they want to encourage learners to think independently. It seems like everything the Mathematics teachers mentioned on how their teaching styles had helped them to plan lessons based on their learners' learning styles, reflected a learner-centred teaching style. These Mathematics

teachers seemed to make their teaching styles flexible and adjusted their teaching to the classroom context which encouraged the learners to become independent.

The Mathematics teachers were further asked how often they had planned their lessons based on the learners' learning styles. The responses are given below.

Teacher A: *It depends on the topic because not all topics allow teachers to consider learners' learning styles and hence some topics are complex even if teacher tries to involve all learners' learning styles it might not help learners to grasp the content taught.*

Teacher B: *Only sometimes because time does allow it to happen.*

Teacher C: *I always consider learners' learning styles because it makes teaching and learning easy.*

Each of the three Mathematics teachers incorporated learners' learning styles in their planning differently and this might have caused by the teachers' understanding about learning styles and time to cover the syllabus, since they were not trained on how to incorporate learners' learning styles in the lesson planning.

Lastly, the Mathematics teachers were asked to indicate the learning styles theory that they used in planning their lessons.

Teacher A: *I used Farrant's learning styles which are inductive and deductive learning styles.*

Teacher B: *I used the handout which I got from the workshop but I do not know the author and that was the reason why I used observation to identify my learners' learning style*'.

Teacher C: *I used Felder and Soloman learning styles.*

Teacher A further stated that during their teachers' training they did not cover much on learning styles except Teacher C, a Master Degree holder who seemed to know more about learning styles. According to the collected information, it seems like the Mathematics teachers in this study knew only a few learning styles.

Summary

The ANOVA test was used to find out whether there was a significant difference between Grade 11 learners' performance and their learning styles in both the pre-test and post-test. The pre-test results yielded no significant difference among the learning style groups which indicated that the four learning style groups were equivalent at the beginning of the study.

The post-test results administered after a three week teaching interaction using different teaching methods showed that there was a significant difference between the Grade 11 learners' performance and their learning styles. The Scheffe test was used to check which pairs of learning styles were significantly different from each another. The significant difference was found between converging and diverging learning style learners as well as between converging and assimilating learning style learners.

Furthermore, the Mathematics teachers indicated that they considered the learning styles of learners in their teaching of Mathematics and held positive views regarding incorporating the learners' learning styles in teaching and learning of Mathematics, which they perceived as resulting in better learners' performance even though it was time consuming. The next chapter presents the summary, conclusion and recommendations of this study.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter provides the summary, as well as the conclusions and recommendations of this study. The possible areas for further research are also identified. This study addressed the effects of learning styles on the learners' performance in Mathematics.

Summary

This research was conducted in order to find out the effects of learning styles on the performance of Grade 11 learners in Mathematics at one Senior Secondary School in the Oshana Education region.

This research addressed the following four questions and one hypothesis:

1. What are the different learning styles utilized by the Grade 11 learners at one Senior Secondary School in learning Mathematics in Oshana Education Region?
2. What effects do the identified learning styles have on the Grade 11 learners' performance in Mathematics?
3. What methods do Mathematics teachers use to identify learners' learning styles?
4. To what extent do Mathematics teachers design teaching methods based on the learners' learning styles?

Hypothesis

To determine whether there was a significant difference in the learners' performance in Mathematics and their learning styles the following null hypothesis was tested.

H_o: There is no significant difference in the learners' performance in Mathematics and their learning styles.

H_1: There is a significant difference in the learners' performance in Mathematics and their learning styles.

The study used both qualitative and quantitative methods to collect data from the Mathematics teachers and learners. The population for this study was all the Grade 11 learners doing the Namibia Senior Secondary Certificate (NSSC) Mathematics at Ordinary Level, and the Mathematics teachers at this level in the Oshana Education Region. Sixty-three (63) Grade 11 learners were randomly selected from the population to form the sample and all three Mathematics teachers at one Senior Secondary School were asked to take part in the study.

Structured interviews were used to gather information from the Mathematics teachers. Kolb's (2005) Learning Style Inventory was administered to the learners in order to determine their learning styles. A pre-test and post-test after three weeks of instruction on Algebra were administered to the learners to find out whether there was a significant difference in their performance in Mathematics and their learning styles.

The Mathematics teachers were interviewed during their free time to avoid interfering with their school work. The Mathematics teachers' responses were recorded and transcribed later after finishing carrying out the research. The researcher used jigsaw method to teach the accommodating learners, think-pair-share to teach the diverging learners, lecture methods to teach the assimilating learners and demonstration method to teach the converging learners. The researcher taught each learning style group separately.

The data collected from the structured interviews were analyzed by means of interpretive analysis, while the Analysis of Variance (ANOVA) was used to determine whether scores from the learning styles groups were significantly different at the probability level of $\alpha = 0.01$.

The results of this study revealed that there was no significant difference between Grade 11 learners' performance in Mathematics and their learning styles in the pre-test. The results showed a significant difference in the learners' performance on the post-test at 0.01 significant level with 59 degrees of freedom after instruction. The converging learning style learners scored higher scores than other learning style groups with the diverging learning style learners scoring low marks in the post-test.

The Scheffe test was carried out to find out which pairs of means were significant on the post-test. The Scheffe test revealed that there was a significant difference between the converging and diverging learning style learners as well as between the

converging and the assimilating learning style learners at significant level 0.01 with 59 degrees of freedom because $F_1 > F_{critical}$.

It seems incorporating the learners' learning styles in learning Mathematics enhanced the Grade 11 learners' performance in Algebra. All learners performed better in the post-test than in the pre-test.

Conclusion

From the results of this study, it seems incorporating the learners' learning styles in the teaching and learning of Mathematics affected the Grade 11 learners' performance positively in Algebra. The learners performed better in the post-test than in the pre-test. The teachers did not seem to indicate clearly the extent to which they selected their teaching methods based on the learners' learning styles.

The understanding of learners' learning styles is important for all teachers to enable them to tailor their lesson plans, teaching strategies and methods to the learners' learning styles in order to meet the needs of all learners in their classrooms. The teachers should experiment with various teaching strategies in classroom in order to help them determine which strategy best meets the learning style needs of their learners.

Recommendations

The following recommendations are made based on the findings of this study.

1. Mathematics teachers should familiarise themselves with knowledge and skills of dealing with different learner learning styles and incorporate these in the teaching of Mathematics.

2. Learning styles should be used both to teach and reinforce Mathematics concepts. For example, the Mathematics teacher could use a linguistic approach such as a story about Trigonometry and then have learners write words that reflect the concept in Mathematics in order to enhance learners' understanding.

Possible areas for further research

The following are the areas for possible future research.

1. The extent to which teachers plan their lessons based on the learners' learning styles.
2. This study used a small sample of learners and teachers. A larger sample and regions could be used in order to find out the impact of learners' learning styles on their performance in Mathematics and other subjects.

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APPENDIX A: PERMISSION FROM PERMANENT SECRETARY

P.O. Box 15017

Oluno

Ondangwa

13th January 2011

To: The Permanent Secretary

Ministry of Education

Private Bag 13186, **Windhoek**

Dear Mr. Ilukena

Re: Request for permission to conduct research at one Senior Secondary School in Oshana Region on the topic: The effects of learning styles on performance of Grade 11 learners in Mathematics.

I am a full time student for a Master's degree in Mathematics Education at the University of Namibia. In partial fulfilment to qualify for my Master's degree, I am required to conduct a research on a topic that is linked to any aspect in the field of Mathematics education. The purpose of my research is to determine the effects of learning styles on the performance of Grade 11 learners in Mathematics.

Oshana region is lowly ranked in the 2010 national rankings. Since my teaching period (2008-2011) at this Senior secondary School, I have observed that the Grade 11 learners have been performing poorly in Mathematics. Substantial number of

researches have been conducted on the effects of learning styles on the performance of learners in different school subjects such as in Applied Statistics and Business Statistics, but it seems no study was conducted on effects of learning styles on the performance of learners in Mathematics as a school subject in Namibia. Given this background, this research will be carried out in order to find out the effects of learning styles on the Grade 11 learners' performance in Mathematics at the selected Senior Secondary School in the Oshana Education Region.

I kindly therefore request for permission from your good office to allow me to use the selected school in Oshana region as my research site for the research project. I will need to conduct the study with three classes doing Mathematics ordinary level. The data will be collected using questionnaire, a pre-test & post-test and Kolb learning styles inventory. The lessons will be based on Algebra, a topic in ordinary level syllabus of Mathematics. I planned to complete the data collection process at the end of March 2012. The school and participants will be assured of confidentiality and anonymity in the final research report, and will be invited to proofread drafts of the report to ensure that details are accurately recorded and reported as were issued. A time table for class sessions with dates and times of visits will be provided, and will not interact with the normal class teaching time slots at the school.

Should you have any queries about this request, please contact me at +264 81 2818061 or my Main Supervisor Dr. Kapenda at +264 81 25 0 5510.

Yours Sincerely

Ms. Patemoshela Silas

HoD: Mathematics & Science, Olukonda Secondary School. Oshikoto region.

APPENDIX B: LETTER TO THE SCHOOL PRINCIPAL

P.O Box 15017

Oluno, Ondangwa

26 February 2012

The Principal

The Selected Senior Secondary School

P/Bag 2028

ONDANGWA

Dear Mr. Nakaziko

Re: RESEARCH TO BE CONDUCTED AT THE SELECTED SENIOR SECONDARY SCHOOL.

I am a full time learner for a Master's degree in Mathematics Education at the University of Namibia. In partial fulfilment to qualify for my Master's degrees, I am required to conduct a research on a topic that is linked to any aspect in the field of Mathematics education. The purpose of my research is to determine the effects of learning styles on the performance of Grade 11 learners in Mathematics.

Oshana region is lowly ranked in the 2009 and 2010 national rankings. Since my teaching period (2008-2011) at this school, I have observed that the Grade 11 learners have been performing poorly in Mathematics. Substantial number of researches has been conducted on the effects of learning styles on the performance of learners in different school subjects such as in Applied Statistics and Business Statistics, but it seems no study was conducted on effects of learning styles on the

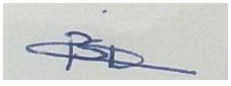
performance of learners in Mathematics as a school subject in Namibia. Given this background, this research will be carried out in order to find out the effects of learning styles on the Grade 11 learners' performance in Mathematics at this Senior Secondary School in the Oshana Education Region.

I kindly therefore, request for permission from your good office to allow me to use the selected school in Oshana region as my research site for the research project. I will need to conduct the study with three classes doing Mathematics ordinary level. The data will be collected using questionnaire, a pre-test & post-test and Kolb learning styles inventory. The lessons will be based on Algebra, a topic in ordinary level syllabus of Mathematics.

I planned to complete the data collection process at the end of March 2012. The school and participants will be assured of confidentiality and anonymity in the final research report, and will be invited to proofread drafts of the report to ensure that details are accurately recorded and reported as were issued. A time table for class sessions with dates and times of visits will be provided, and will not interact with the normal class teaching time slots at the school.

Should you have any queries about this request, please contact me at +264 81 2818061 or my Main Supervisor Dr. Kapenda at +264 81 25 0 5510.

Yours Sincerely



Ms. Patemoshela Silas (HOD: Mathematics & Science, Olukonda Secondary School. Oshikoto region).

APPENDIX C: CONSENT FORM FOR PARENTS

Please fill out this consent form and return it.

I, _____, the parent of _____ a Grade 11 learners at a selected school hereby give consent for my child to be a subject in the study entitled "*effects of learning styles on the Grade 11 performance' in Mathematics*" by attending the sessions, sit for the tests and completing the Kolb Learning styles Inventory.

I understand that:

- My child is under no obligation to participate, and may withdraw from the study at any point prior to the publication or presentation of research results.
- Anonymity will be maintained through the use of pseudonyms. The name of my child will not be reported.
- The research will be used for academic and professional presentations and publications.

_____

Signature **Date: _____/___/2012**

APPENDIX D: CONSENT FORM SIGNED BY THE SCHOOL PRINCIPAL.

Consent form for the School Principal

…….. is hereby given permission to use The selected Senior Secondary School as the research site for the research study she is required to conduct in partial fulfilment for the Master's degrees in Education of the University of Namibia.

I understand that:

- The data for analysis will be collected by means of interviewing individual Mathematics teachers and the Grade 11 ordinal level Mathematics learners, administering the Mathematics pre-test & post-test and the Kolb Learning Style Inventory.
- The information from these instruments will be used in the final report of this study.

I have been assured that the school and the teachers will have anonymity in the final report and the information collected will be used for the sole purpose of the study.

_____ __/ _____/2012

Principal's signature Date

APPENDIX E: INTERVIEW QUESTIONS FOR MATHEMATICS TEACHERS

A. Background information and teacher preparation

1. What teaching qualification do you have?
2. What subjects do you teach?
3. What Grade levels do you teach?

B. Learning styles

1. What types of learning styles do your learners use to study Mathematics? Can you please explain more on the learning styles you have mentioned?
2. What perceived effects do the learning styles you mentioned have on the learners' performance in Mathematics?
3. Apart from the perceived effects you have stated earlier, what are your views on the effects of learning styles in general?
4. What methods do you use to identify your learners' learning styles?
5. How do your own learning styles help you to identify your learners' learning styles?
6. What teaching methods do you use to teach Mathematics?

C. **Use of learning styles to plan lessons**

7. How do you make sure that your lessons are based on the learners learning styles?
8. How do your teaching styles help you to plan the lessons based on the learners' learning styles?
9. How often do you plan the lessons based on the learners' learning styles?
10. Which psychologist learning styles do you use in planning your lessons?

APPENDIX F: LEARNERS' LEARNING STYLES INVENTORY

Instructions: Tick (√) in the appropriate column on the right, based on how much you agree or disagree with item.

Items	Strongly Agree	Agree	Not Sure	Disa gree	Strongly Disagree
1. I learn Mathematics best when I work alone.					
2. I learn Mathematics best when I join groups.					
3. I learn Mathematics best when I manipulate the materials.					
4. I learn Mathematics best when I look at the pictures.					
5. I learn Mathematics best when I explore patterns and relationships of numbers.					
6. I learn Mathematics best when I listen to the teacher.					
7. I learn Mathematics best when I follow (pursue) my interests.					
8. I learn Mathematics best when I organise materials myself.					
9. I like solving problems in Mathematics.					
10. I learn Mathematics best when it is in the form of a song.					
11. I learn Mathematics' practical problems best when I work alone.					
12. I learn best by working with abstract patterns/ relationships. e.g. start working from simple to complex concepts .					
13. I learn Mathematics best by interacting with space. e.g moving around the class checking how others have solved a problem.					
14. I learn Mathematics projects best when I work alone.					
15. I learn Mathematics best when I know where I will use the content I taught in school in everyday life.					
16. I learn Mathematics best by comparing myself to others.					

17. I learn Mathematics best when imagining things. e.g a cuboid, them I think of a box.					
18. I learn Mathematics best when working in a small group.					
19. I learn Mathematics best when creating models.					
20. I am good at reasoning skills in Mathematics.					
21. I like touch and talk method in Mathematics.					
22. I am good at physical activities in Mathematics.					
23. I like individual work in Mathematics.					
24. I am good at building puzzles in Mathematics.					
25. I am good at decision making in Mathematics.					
26. I learn Mathematics best when I classify figures or objects in Mathematics.					
27. I like to work with numbers in Mathematics.					
28. I am good at understanding myself in Mathematics.					
29. I like to learn Mathematics with a lot of friends.					
30. I am good at understanding others in Mathematics.					
31. I learn Mathematics better by drawing and sketching pictures.					
32. I like to ask questions in Mathematics' lessons.					

Adapted from Kolb, A.D. (2005). **Learning Styles Inventory-version 3.1**. Cleveland: Case Western Reserve University.

APPENDIX G: PRE-TEST IN ALGEBRA **MARKS: 30**

1. Write down the number of terms in the following algebraic expressions.

(a) $3a - 2b + 4c$ ---------- [1]

(b) $2(3x + 2)$ ---------- [1]

2. Simplify the following

(a) $2a + 3 + 2 + a =$---------- [1]

(b) $-b + 2a - 3a =$ ---------- [1]

3. Remove the brackets.

(a) $3a^2(2a - 2a^3b)$ [1]

(b) $2(x + 3y) - 3(2x + y)$ [2]

(c) $-b^2 + b(6 + b)$ [1]

4. Express as a single fraction

(a) $\frac{1}{a} + \frac{1}{b}$

[2]

(b) $\frac{4}{t} - \frac{3}{t^2}$ [2]

(c) $\frac{a}{b} \times \frac{b^2}{a}$ [1]

(d) $\frac{3x^2y}{2} \div \frac{6x^8}{8y}$ [2]

(e) $\frac{x^2-2x}{x^2-4}$ [3]

5. A man is x years old.

(a) How old will he be 10 years from now? [1]

(b) How old was he 10 years ago? [1]

(c) How old will he be in *a* years time? [1]

6. If a = 1 and b = -2, find:

(a) $a + b$ [1]

(b) $4a^2 + 5b^2$ [2]

7. Solve for *x*.

(a) $x + 11 = 20$ [1]

(b) $6 - 3x = 5x + 1$ [2]

8. Factorize completely

(a) $3x^2 + x^2y$ [1]

(b) $4pqr - 12p + 16pr$ [2]

Pre-test memo **Marks: 30**

1.

(a) $3a - 2b + 4c$ = 3 terms [1]

(b) $2(3x + 2)$ = 1 term [1]

2. **(a)** $2a + 3 + 2 + a = 3a + 5$ [1]

(b) $-b + 2a - 3a = -a - b$ [1]

3. **(a)** $3a^2(2a - 2a^3b)$ [1]

$= 6a^3 - 6a^5b$

(b) $2(x + 3y) - 3(2x + y)$ [2]

$= 2x + 6y - 6x - 3y$

$= -4x + 3y$

(c) $-b^2 + b(6 + b)$ [1]

$= -b^2 + 6b + b^2$

$= 6b$

(d) $\frac{x^2-2x}{x^2-4}$

$= \frac{x(x-2)}{(x-2)(x+2)}$ [3]

$= \frac{x}{(x+2)}$

4. **(a)** $\frac{1}{a} + \frac{1}{b}$ [2]

$= \frac{b+a}{ab}$

(b) $\frac{4}{t} - \frac{3}{t^2}$ [2]

$= \frac{4t-3}{t^2}$

(c) $\frac{a}{b} \times \frac{b^2}{a}$ [1]

$= \frac{ab^2}{ba}$

$= b$

(d) $\frac{3x^2y}{2} \div \frac{6x^3}{8y}$ [2]

$= \frac{3x^2y}{2} \times \frac{8y}{6x^3}$

$= \frac{24x^2y^2}{12x^3}$

$= \frac{2y^2}{x}$

5. A man is x years old.

(a) $x + 10$ [1]

(b) $x - 10$ [1]

(c) $x + a$ [1]

6.

(a) $a + b$ [1]

$= 1 - 2$

$= -1$

(b) $4a^2 + 5b^2$ [2]

$= 4(1)^2 + 5(-2)^2$

$= 4 + 20$

$= 24$

7. **(a)** $x + 11 = 20$ [1]

$x = 20 - 11$

$x = 9$

(b) $6 - 3x = 5x + 1$ [2]

$6 - 1 = 5x + 3x$

$\frac{5}{8} = \frac{8x}{8}$

$x = \frac{5}{8}$

8. **(a)** $3x^2 + x^2y$ [1]

$= x^2(3 + y)$

(b) $4pqr - 12p + 16pr$ [2]

$= 4p(qr - 3 + 4r)$

APPENDIX H: LESSON PLANS USED ON DIFFERENT DAYS

LESSON PLAN 1

Subject: Mathematics Grade: 11

Topic: algebraic expressions: basic operations (+ & -)

Objectives: By the end of the lesson, learners should be able to use letters to express generalised numbers and express basic processes algebraically.

Teaching resources: geometrical shapes packages

Content	**Accommodators ' activities**	**Assimilators ' activities**	**Divergings' activities**	**Convergings ' activities**
Introduction - Teacher gives a package of shapes to each group and asks them to group the shapes in the way it suites them and asks the learners to explain more on their classifications. - Teacher further asks learners on the learner's grouping and hence	Group the shapes and explain more on their classification. Note down the topic.	Group the shapes and explain more on their classification. Note down the topic.	Group the shapes and explain more on their classification. Note down the topic.	Group the shapes and explain more on their classification. Note down the topic.

introduces the topic for a day.				
<u>Teaching-Learning Phase</u> • Teacher asks learners use letters to represent each shape with a letter and not down how many of each shape do they have. Example: 2 circles = 2c, 3 squares =3s • Teacher asks to add up all the like shapes in the whole class as well as the unlike terms. Like terms can be added but unlike terms can not. • Example: 1. 2c + 2c = 4c , 2. 2c + 3b = 2c + 3b	Learners use the jigsaw method to answer the question. Learners add up the like shapes and note down how many they are.	Teacher works on the board together with learners.	Teacher asks a learner to come and solve the problem on the board with the help of others. Learners add up the like shapes and note down how many they are.	Learners work on the activities individually. Learners add up the like shapes and note down how many they are.

<u>Assessment:</u> Simplify as far as possible 1. 3x + 6y - 2x +y 2. 6-3a + 2 – 4a 3. 5p – 2q + 3r +2p + 5q +4s	Learners work using jigsaw method	Solve problems individually.	Group discussions and presentation.	Learners work on the activities individually.
<u>Conclusion:</u> - highlights the lesson main points. e.g Like terms can be added and subtracted but unlike terms can not. - Give feedback to the activity. Teacher invites questions from the learners. <u>Homework:</u> read multiplication and division of terms.	Listen and take notes	Listen and take notes	Ask question and take notes.	Ask question and take notes.

LESSON PLAN 2

Subject: Mathematics Grade: 11

Topic: *multiplication and division*

Objectives: By the end of the lesson, learners should be able to and express basic processes algebraically.

Teaching resources:

Content	**Accommodators ' activities**	**Assimilators' activities**	**Divergings ' activities**	**Converging s' activities**
Introduction Teacher asks learners the questions on the previous lesson. Teacher writes the expression on multiplication and division on the board and asks learners to solve it. 1. $-3x^2y \times -4x^3y$ 2. $\frac{-10a^3b}{-2ab^4}$	Learners discuss the problem and give the answer.	Teacher explains how to solve it and learners listen.	Learners discuss and give the feedback.	Each learner writes their answer on their note.
Teaching-Learning Phase Examples solved: 1. $3x^3y^2 \times -4xyz$ 2. $(-3ab^3c^3)^3$ 3. $\frac{14x^2}{7x^3}$	Teacher gives an example first and then groups learners to use the jigsaw method.	Teacher explains using the lecturing method. Learners work individually on the activities.	Teacher writes the question on the board and asks learners to solve it using the think-pair method.	Teacher demonstrates an example on the chalkboard and then asks learners to solve a given problem individual.

<u>Assessment:</u> <u>worksheet</u> <u>simplify</u> 1. 4(5a+3) 2. $\frac{3x^4yz}{-6xy^5}$ 4. $6x^3(2x)^2$ 5. $4(x + 3)$	Learners work in jigsaw method.	Solve problems individually.	Group discussions.	Learners work on the activities individually.
<u>Conclusion:</u> - Gives the feedback to the activity. - motivates learners to ask questions. <u>Next topic:</u> Gives a homework in $y=mx + c$. page 72	Listen and take notes.	Listen and take notes.	Present their findings and ask questions.	Notes down the main lesson points and ask questions based on real life situations.

LESSON PLAN 3

Subject: Mathematics Grade: 11

Topic: Substitution

Objectives: By the end of the lesson, learners should be able to substitute numbers for words and letters in formulae.

Teaching resources:

Content	**Accommodators ' activities**	**Assimilators' activities**	**Divergings' activities**	**Convergings' activities**
Introduction - Teacher gives a scenario: 'suppose you have a cow that you wish to exchange for goats. How many goats will you ask?' - Teacher relates the scenario to substitution and hence introduces the topic.	Give their views on the scenario. Note down the topic.	Give their views on the scenario. Note down the topic.	Give their views on the scenario. Note down the topic.	Give their views on the scenario. Note down the topic.
Teaching-Learning Phase Examples solved: If $a = 1$, $b = 2$, $c = 3$, and $d = \frac{3}{4}$. Evaluate, 1. $3a^3b$ 2. $8b^3cd^2$	Teacher gives an example first and then groups learners to use the jigsaw method.	Teacher explains using the lecturing method. Learners work individually	Teacher uses the think-pair method teacher the learners and gives a pair work	Teacher demonstrates an example based on real life situations on the board

		on the activities.	activities.	and asks the learners to work on the activities individually.
Assessment: 1. $3abc - 3d$ 2. $3(b - 2c)^2$ 3. $3ab + c(d + 2)$	Learners work using jigsaw method.	Solve problems individually.	Group discussions ..	Learners work on the activities individually.
Conclusion: - asks learners where substitution used in our every day life. e.g. Currency exchange,, buying and selling. - Give feedback to the activity. - Give learners a chance to ask questions if any. Next topic: Construction of linear equation.	Listen and take notes	Listen and take notes		

APPENDIX I: POST-TEST FOR THE LEARNERS AFTER INTERVENTION

Post-test **Marks: 30**

1. Simplify as far as possible

(a) $3x + 6y - 2x + y$ **[1]**

(b) $(-3ab^2c^3)^3$ **[2]**

(c) $\frac{3x^4yz}{-6xy^5}$ **[2]**

2. If $a = -3$ and $b = 2$ and $c = -1$ and $d = 0$ and $e = 1$.

Find the value of $2be - 4ad$. [2]

3. Gerdus thinks of a number. He subtracts three from the number, doubles the answer and then gets an answer of 12. Find the number Gerdus was thinking of. [2]

4. Solve the equation

$3 - 2(a-2) = 10$ [2]

5. Expand the following expressions

(a) $2x^2(2xy - 4y^3z)$ [1]

(b) $(x + 3)(y + 4)$ [2]

(c) $(b - 3)^2$ [2]

6. Factorise completely.

(a) $16a^2b - 24a^4b^2c$ [1]

(b) $25x^2 - 9y^2$ [2]

(c) $bx + by + ax + ay$ [2]

7. Express as single fraction.

(a) $\frac{2}{x-3} - \frac{1}{x+4}$ [3]

(b) $\frac{6}{(a+2)} \times \frac{x^2-4}{3}$ [2]

(c) $\frac{3}{4x} + \frac{2}{x}$ [2]

(d) $\frac{2x}{x^2-4} \div \frac{1}{x-2}$ [3]

Post-test Memo **Marks: 30**

1.

(a) $3x + 6y – 2x + y$

$= 3x – 2x + 6y + y$
$= x + 7y$ [1]

(b) $(-3ab^2c^3)^3$

$=-3^3a^3b^{2\times3}c^{3\times3}$
$= -27a^3b^6c^9$ [2]

(c) $\frac{3x^4yz}{-6xy^5}$ [2]

$= \frac{-x^{4-1}y^{1-5}z}{2}$

$= \frac{-x^3z}{2y^4}$

2. $2be – 4ad$ [2]

$= 2(2)(1) – 4(-3)(0)$
$= 4$

3. $2(x-3) = 12$

$2x - 6 = 12$
$2x = 12 + 6$ [2]
$2x = 18$
$x = 9$

4. $3-2(a-2) = 10$ [2]

$3 - 2a + 4 = 10$
$-2a = 3$
$a = -\frac{3}{2}$

5. (a) $2x^2 (2xy – 4y^3z)$ [1]

$= 4x^3y – 8x^2y^3z$

(b) $(x + 3)(y + 4)$

$= xy + 4x + 3y + 12$ [2]

(d) $(b - 3)^2$

$= (b - 3)(b - 3)$ [2]

$= b^2 - 3b - 3b + 9$

$= b^2 - 6b + 9$

6. (a) $8a^2b(2 - 3a^2bc)$

$=16\,a^2b - 24a^4b^2c$ [1]

(b) $(5x - 3y)(5x + 3y)$

$=25x^2 + 15xy - 15xy - 9y^2$

$=25x^2 - 9y^2$ [2]

(c) $b(x + y) + a(x + y)$

$= (b + a)(x + y)$ [2]

7. (a) $\frac{2}{x-3} - \frac{1}{x+4}$

$= \frac{2(x+4)-1(x-3)}{(x-3)(x+4)}$

$= \frac{2x+8-x+3}{(x-3)(x+4)}$

$= \frac{(x+11)}{(x-3)(x+4)}$ [3]

(b) $\frac{6}{(a+2)} \times \frac{a^2-4}{3}$

$= \frac{6}{(a+2)} \times \frac{(a-2)(a+2)}{3}$

$= 2(a-2)$

$= 2a - 4$ [2]

APPENDIX J: CLASS ACTIVITY GIVEN TO THE LEARNERS IN SOLVING QUADRATIC EQUATIONS LESSON.

Solve the following quadratic equation

$a^2 - 8a + 12 = 0$

GROUP A: FACTORISATION

$a^2 - 8a + 12 = 0$

$(a^2 - 2a) - (6a + 12) = 0$

$a(a - 2) - 6(a - 2) = 0$

$(a - 6)(a - 2) = 0$

$a - 6 = 0$ $a - 2 = 0$

$a = 6$ or $a = 2$

GROUP B: COMPLETING THE SQUARE

$a^2 - 8a + 12 = 0$

$a^2 - 8a + (-4)^2 = -12 + (-4)^2$

$\sqrt{(a - 4)^2} = \sqrt{4}$

$a - 4 = \pm 2$

$a - 4 = 2$ $a - 4 = -2$

$a = 6$ or $a = 2$

GROUP C: USING FORMULA

$a^2 - 8a + 12 = 0$

$a = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$= \frac{-(-8) \pm \sqrt{(-8)^2 - 4(1)(12)}}{2(1)}$

$= \frac{8 \pm \sqrt{64 - 48}}{2}$

$= \frac{8 \pm \sqrt{16}}{2}$

$= \frac{8 \pm 4}{2}$

$a = \frac{8+4}{2}$ $\qquad$ $a = \frac{8-4}{2}$

$a = 6$ $\qquad$ **or** $\qquad$ $a = 2$

APPENDIX K: ENGLISH WORDS AND THEIR CORRESPONDING ALGEBRAIC EXPRESSIONS.

ENGLISH	**ALGEBRAIC EXPRESSION**
The **sum** of a number and 3	$x + 3$
A number **increased** by 6	$a + 6$
5 **more** than a number	$b + 5$
6 **added** to a number	$m + 6$
A number **subtracted** from 7	$7 - x$
3 **subtracted** from a number	$y - 3$
A number **decreased** by 4	$x - 4$
2 **less** than a number	$y - 2$
The **product** of a number and 5	$x \times 5 = 5x$
A number **multiplied** by 8	$d \times = 8d$
9 **times** a number	$9 \times p = 9p$
A number **divided** by 6	$\frac{m}{6}$
Half a number	$\frac{x}{2}$

APPENDIX L: PRE-TEST AND POST-TEST RESULTS

Pre-test results: d – diverging, **as** – assimilating, **ac** – accommodating,

c – Converging.

d	**As**	**C**	**Ac**	$\mathbf{d}^2$	$\mathbf{as}^2$	$\mathbf{c}^2$	$\mathbf{ac}^2$
14	13	11	14	196	169	121	196
12	10	14	13	144	100	196	169
10	11	13	16	100	121	169	256
12	8	13	11	144	64	169	121
13	14	12	12	169	196	144	144
10	12	11	7	100	144	121	49
14	13	9	8	196	169	81	64
9	8	13	14	81	64	169	196
11	13	15	10	121	169	225	100
15	7	9	13	225	49	81	169
12	14	11	14	144	196	121	196
12	12	14	10	144	144	196	100
15	14	13	9	225	196	169	81
14	10	10	12	196	100	100	144
10	13	12	15	100	169	144	225
	9	14			81	196	
	12				144		
$\sum d$ =1 83	$\sum as$ = 207	$\sum c$ =1 94	$\sum ac$ = 178	$\sum d^2$ =2 195	$\sum(as)^2$=2 275	$\sum c^2$ = 2402	$\sum(ac)^2$ =2 210

Post-test results: d – diverging, **as** – assimilating, **ac** – accommodating,

c - Converging.

d	**As**	**C**	**Ac**	$\mathbf{d}^2$	$\mathbf{as}^2$	$\mathbf{c}^2$	$\mathbf{ac}^2$
17	19	16	18	289	361	256	324
14	15	20	16	196	225	400	256
15	16	22	20	225	256	484	400
11	12	18	13	121	144	324	169
16	20	19	18	256	400	361	324
13	18	18	10	169	324	324	100
20	14	14	14	400	196	196	196
13	12	18	24	169	144	324	576
12	16	23	14	144	256	529	196
19	12	14	18	361	144	196	324
18	22	15	19	324	484	225	361
17	16	20	14	289	256	400	196
18	18	16	12	324	324	256	144
13	13	14	14	169	169	196	196
12	17	16	22	144	289	256	484
	10	20			100	400	
	13				169		
$\sum d =$ 228	$\sum as =$ 245	$\sum c =$2 83	$\sum ac =$24 6	$\sum d^2 =$3 580	$\sum(as)^2$ =4241	$\sum c^2 =$5 127	$\sum(ac)^2 =$ 4147