

**EXPLORING THE INFLUENCE OF A MULTILITERACIES APPROACH ON GRADE  
11 PHYSICAL SCIENCES LEARNERS' SENSE MAKING AND DISPOSITIONS  
TOWARDS GRAPHS OF MOTION**

**A thesis submitted in partial fulfilment of the requirements for the degree**

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**By**


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## DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my original work. It has not been previously submitted in any form for assessment or degree in any other higher education institution. All ideas, quotations and other materials used in this study derived from the work of other people have been indicated in the list of references.

Signature:

A handwritten signature in black ink, appearing to read 'Muyak', written in a cursive style.

Date: 24/01/2017

## **DEDICATION**

This piece of work is dedicated to my husband and our son for all the love and for supporting me throughout the research journey. You are a blessing to me.

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First and foremost, I would like to thank the Almighty Father for his grace and for giving me faith, strength and wisdom to complete this study. I would like to express my sincere gratitude to all who made great contributions to this study. I would like to express my highest and most sincere gratefulness and thankfulness to my supervisor Mr. Kavish Jawahar for his endless support, guidance and motivation throughout the study. Without your productive and positive criticisms, comments and unwavering support, this work would have not been a success. My sincere gratitude goes to Professor Kenneth Ngcoza, your guidance and words of encouragement makes me a better researcher. I am and forever will be grateful for your patience, inspiration and encouragement throughout my research journey.

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## **ABSTRACT**

Namibian students perform poorly in Physical Sciences and the Physics component in particular (DNEA, 2013). The Namibian Senior Secondary Certificate (NSSC) Examiner's report (DNEA, 2014) also reveals that many Physical Science learners have difficulties demonstrating an understanding of basic physics required for working with kinematic graphs (graphical representation of motion). Kinematics is an important tool in understanding the motion of objects - whether translational, oscillatory or circular. In kinematics, the relationships between distance, displacement, speed, velocity or acceleration and time are represented in graphs of motion. In teaching the topic, using graphs can be an alternative to the use of abstract formulas, or formulas can be used along with graphical representations to facilitate student understanding (Bêhzak, 2006).

This study explored the influence of the multiliteracies approach on grade 11 Physical Science learners' dispositions and sense making towards graphs of motion. The intervention being investigated is informed by the Pedagogy of Multiliteracies (PoM) framework by Cazden et al., (1996) with the focus on overt instruction, situated practice, critical framing and transformed practice using semiotic patterns of meaning, in conjunction with Vygotsky's (1978) social constructivism theory - particularly, its notion of mediation.

This action research study employed the interpretive paradigm. Data were collected using a pre-test, stimulated recall interviews, lesson observations, a post-test and learners' reflections. Data were coded and the codes then categorized into different themes in order to answer the research questions. The findings of this study were that learners are better able to make sense of graphs of motions when a PoM approach is employed. Their dispositions towards graphs of motion also improved as a result of the PoM intervention, due to it enabling a better understanding of kinematics concepts.

This study also contributed to the professional development of the researcher, particularly in terms of it contributing to a broader understanding of the research and possible usefulness of semiotic mediation in science education. Implications of the study include the possibility of including the PoM approach in science teacher education and training programme curricula.

**Key words:** kinematics, graphs of motion, visual literacy, graphicacy, sense making, disposition, social constructivism, mediation, Pedagogy of Multiliteracies, overt instruction, situated practice, critical framing, transformed practice

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## **LIST OF ABBREVIATIONS AND ACRONYMS**

DNEA:	Directorate of National Examination and Assessments
GoM:	Graphs of Motion
ICTs:	Information Communication Technologies
IVLA:	International Visual Literacy Association
L:	Learner
NCBE:	National Curriculum for Basic Education
NSSC:	Namibia Senior Secondary Certificate
NSSCO:	Namibia Senior Secondary Certificate Ordinary level
QDA:	Qualitative Data Analysis
PoM:	Pedagogy of Multiliteracies
SI:	International System of Units

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# CHAPTER 1

## CONTEXT OF THE STUDY

### 1.1 Introduction

The goal of this study was to explore the influence of the Pedagogy of Multiliteracies (PoM) approach on Namibian Grade 11 Physical Sciences learners' sense making and dispositions towards graphs of motion. The need for this study was triggered by various examiners reports such as the Namibian senior secondary certificate Physical Science examiners report for both ordinary and higher levels as well as some international studies that will be discussed later. These reports reveal poor performance by learners in the Physical Science section involving distance, displacement, speed, velocity and acceleration graphing, and graphical interpretation skills related to graphs of motion.

This chapter presents an overview of the context of the study. Learners' sense making of graphs and their dispositions towards graphs of motion is discussed. Reference is made to both the international, and national contexts (the Namibian National Curriculum and the Namibia Senior Secondary Certificate Ordinary level (NSSCO) Physical Science syllabus expectations), as well as earlier research findings. This chapter also discusses the rationale for the study, highlighting the problem statement, the potential value of this study, theoretical framing of the study and the key concepts used. A brief outline of the thesis chapters is provided before this chapter concludes.

### 1.2 Background of the study

#### 1.2.1 International context

Science education deals with sharing of science content and process with individuals. It has been argued by Akarsu (2010) and Kola (2013) that science educators are mainly concerned with sharing science content and process with individuals not traditionally considered part of the scientific community. Science education includes dealing with the teaching of science concepts, and with methods of teaching and addressing misconceptions held by learners regarding science concepts (Kola, 2013). Kola (2003) further emphasised that science education is very important for the development of any nation and this is why it needs to be taken very seriously at all institutions of learning (ibid). When learning complicated scientific

concepts, interacting with multiple forms of representation such as diagrams, graphs and equations can bring unique benefits (Ainsworth, 2008). This is not an exception in the case of kinematics concepts such as displacement, velocity and acceleration.

Pedagogy of Multiliteracies, as introduced by a group of researchers called the “New London Group” (Cazden, Cope, FairClough, Gee, Kalantzis, Kress, Luke, Luke, Michaels & Nakata, 1996), has been the topic of vivid research in science education. Turbill (2002) highlights that we have entered “the age of multiliteracies” in which “meaning making” involves being able to ‘read’ not only print text but also colour, sound, movement, and visual representations. Cazden et al., (1996) argues that the learning processes need to recruit rather than attempt to ignore and erase the different subjectivities, interests, intentions, commitments, and purposes that learners bring to learning as these are of great advantages to them. All the above need to be acknowledged as learners are not confined to their classrooms where learning took place but they use different sources to construct their knowledge. As a result this will shape their learning quality and experiences through the use of multiple representations. Unfortunately, there is considerable evidence to show that learners often fail to exploit these advantages, and in the worse cases inappropriate combinations of representations can completely inhibit learning (Ainsworth, 2008). In other words, multiple representations are powerful tools but like all powerful tools they need careful handling if learners are to use them successfully.

Science education relies heavily on the use of visuals to present technical information. According to Stokes (2001), visual information is presented in pictorial or graphic images. In Physical Sciences these images are diverse, ranging from realistic drawings and photographs to highly abstract diagrams and graphs. Graphs in particular, are used broadly in science and mathematics and they feature prominently in the kinematics section of the physics component of the Physical Sciences syllabus. These graphs are called kinematic graphs or graphs of motion (GoM). The terms ‘graphs of motion’ and ‘kinematic graphs’ will be used interchangeably in this study when referring to distance versus time, displacement versus time, speed versus time, velocity versus time and acceleration versus time graphs. Distance and speed are scalar quantities (they involve magnitude without direction) while displacement, velocity and acceleration are vector quantities (they include both magnitude and direction).

The table below shows the different types of kinematic graphs and what the slope and area of each graph, represents. For example, the slope of a curve or shape of a displacement versus time graph will be equal to the velocity of the object in motion, the steepness is indicative of the magnitude of the velocity, and zero slope depicts an object at rest. This is further explained in the literature review chapter (Section 2.2.3).

**Table 1. Meaning of the slope and area of kinematic graphs**

Graph	Slope	Area under the graph
Distance versus time	Speed	-----
Displacement versus time	Velocity	-----
Speed versus Time	-----	Distance
Velocity versus Time	Acceleration	Displacement
Acceleration versus time	-----	Change in velocity

Bektasli (2006), reiterate that there are some difficulties for learners when they use kinematic graphs. The most common ones are confusing slope and height of the graph, distinguishing slope and area, “graph as a picture” error, confusing distance and velocity, graphical interpretation, graph construction and their mathematics background, and relationships between the graphs. He further highlighted that slope and height are two critical components of graphs and they need to be understood to improve graphing construction and interpretations abilities. In addition to that, he stated that the understanding of slope and height has an important role especially in transition from one kinematic graph to another. For example, when a velocity versus time graph is given, learners need to know the difference between the slope and height because in a velocity versus time graph the height (y-axis reading) is the velocity whereas the slope of the line is the acceleration. This is because they mostly finds it difficult to differentiate slope and height when they are represented on different kinematic graphs hence this causes confusion.

Additionally, Beichner (1994) carried out a study with high school learners who were taught kinematics using the traditional method. Learners were given a test on their understanding of kinematics graphs by testing their graphical skills experiences and their graphical interpretation skills. The study reveals that learners do not know when to use the slope or

area for interpretation of a given graph. If they do not have a clear understanding of using slope and area, then they cannot interpret the graphs correctly and as a result they cannot make connections between graphs (Beichner, 1994). If a velocity versus time graph is given, learners need to calculate the slope to get acceleration. In addition, they also need to know what slope, height and area represent to be able to separate them from each other (ibid). This is very common to learners and it often lead to misunderstanding resulting in learners expressing these kinds of errors when interpreting graphs of motion.

GoM's are meant to convey important concepts, but learners at all ages demonstrate difficulties interpreting them (Zucker, Kay & Staudt, 2014). Several studies in the world reveal that learning graphs of motion requires many different tasks to be performed, skills developed and concepts understood (Ainsworth, 2008). For example, Beichner (1994) conducted the study on his learners understanding of kinematics graphs and found out that many learner's produce incorrect velocity vs time graphs covered by a moving bicycle. This is because they interpret kinematic graphs differently than the scientific convention, according to their own knowledge when asked to draw velocity versus time graphs of bicycles going uphill, downhill or on a gravel road (ibid). This is because learners tend to answer questions based on what they know considering their own prior knowledge rather than what is expected of them from the kinematic graphs interpretations.

Exploring student difficulties related to kinematics graphs is important for inventing instructional strategies to reduce or eliminate the problems learners experience in understanding them. Pedagogy of Multiliteracies (Cazden et al., 1996) recognizes visual literacy as one of many literacy demands in science education and the need for a significant shift from traditional print-based literacy to 21st century multiliteracies reflecting the impact of communication technologies and multimedia on the evolving nature of texts, as well as the skills and dispositions associated with the production, evaluation, and distribution of those texts (Borsheim, Meritt & Reed, 2008). The increasing need to support learners' sense making involving multiliteracies opens a space for creative science teaching approaches in order to overcome the trend of poor performance in Physical Sciences at school. Furthermore, it is possible that developing learner's visual literacy through a multiliteracies approach might

influence not only learners' sense making but also disposition to the topic, by altering learner's understanding as well as voluntary behaviours towards graphs of motion.

The use of graphs is essential in kinematics because kinematics graphs shows the relationship between the variables (Bektasli, 2006). Using kinematics graphs might help learners learning as well as improve their problem solving skills. Bektasli (2006) added that, graphs can facilitate learners' sense making and can contribute to their learning, but they need some basic skills to understand graphs. The PoM approach provide learners with skills to learn, understand and interpret GoM problems.

I have developed an interest in kinematic graphs since graphs are widely used in Physical Sciences, and are an essential aspect of Physical Sciences learner's development of visual literacy skills but pose a challenge to science learners. According to Zucker, Kay and Staudt (2014), better instruction, curricular resources, and instructional tools are needed to help students learn to understand and use graphs. Using the PoM approach during teaching and learning in science classrooms provides teachers and students with a different context than their predecessors faced a generation ago (Zucker et al., 2014).

### **1.2.2 National context**

The Namibian Natural Sciences subject curriculum includes Physical Sciences which covers Chemistry and Physics in grades 8-12. In the Physics component, learners are also required to learn graphs of motion which learners find challenging (as mentioned earlier). The Namibia, National Curriculum for Basic Education [NCBE], (2010) highlight that the preparation for a knowledge-based society requires a learner-centred approach to teaching and learning. This means that the "point of departure is always what the learners already know and can do, then acquiring new knowledge through ways of working which are relevant and meaningful for them, and learning how to apply their knowledge creatively and innovatively" (2010, p. 4). An integral part of this approach is the integration of Information Communication Technologies (ICTs) as a tool to enhance teaching and learning (Namibia. NCBE. 2010).

The curriculum further states the teaching and learning in science classroom must recognise that, as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation and evaluation to use the information effectively (Namibia. NCBE. 2010, p. 1). There is a need to provide opportunities to learners to develop their skills in Physical science more especially when learning graphs of motions

(Kinematic graphs) because these skills cannot be developed in isolation (Namibia, Namibia Senior Secondary Certificate Ordinal level [NSSCO], 2009).

Grade 11 Physical Science learners find it difficult to determine the distance covered by a moving object, which is represented by the area under the speed vs time graph (Directorate of National Examination and Assessment [DNEA] examiner's report, 2010 & 2012). Likewise, the examiner's report (DNEA, 2014) also reveals that learners could not explain the motion of cars correctly when they are moving with a changing velocity. In addition to that, one examiner's report (DNEA, 2009) also reported that the use of graphs to calculate velocity is problematic to learners as they could not use the graph to calculate velocity, speed or acceleration.

As I uncovered these difficulties, both in my personal teaching and learning experiences as well as in the literature, there was increasing impetus to embark on a project exploring the use of a PoM as a strategy that might influence learners' sense making and disposition towards learning graphs of motion.

### **1.3 Rationale**

#### **1.3.1 Problem statement**

Graphicacy is an important skill and features prominently in the kinematics section of Physics curricula. The use of graphs in a physics classroom is important because they represent much information and show important relationships between different variables. In kinematics, the relationship between distance, displacement, speed, velocity, acceleration and time can be presented visually for pedagogical purposes to facilitate learners understanding since scientists commonly use such graphs for representing data. However, there are many challenges associated with learning graphs of motion, as highlighted earlier.

As a Physical Science teacher, I have noted that learners have problems answering questions on graphs of motion. The consistent poor performance in Physical Science as a subject and in the graphs of motion section in particular is cause for concern. I have consulted the national examination examiners reports from the Directorate of National Examination and Assessment (DNEA) and the same problem is highlighted in almost all the reports from 2008 to 2014. The reports further reveal that learners' problematic performance in Physical Science, especially

in the topic of speed, velocity and acceleration is due to a lack of understanding of graphical representation of motion (DNEA, 2008; DNEA, 2009; DNEA, 2010; DNEA, 2013; DNEA, 2014).

Due to Namibian Physical Sciences learners experiencing challenges with graphs of motion, their performance in the kinematics section of Physics is poor. There is no literature found on the influence of a PoM approach to possibly resolving this problem in Namibia. I thus have a strong rationale for exploring the influence of PoM teaching intervention, on Namibian Physical Sciences learner's sense making and dispositions towards graphs of motion.

### **1.3.2 Potential value of the study**

This research aimed to explore learners' sense making and dispositions before and after an intervention framed by PoM and focusing on the fundamental quantities of motion i.e. distance, displacement, speed, velocity, acceleration and time. Conducting research on kinematic graphs may be of significant value to me as a Physical Science teacher, to the learners and to other Physical Science teachers as the findings may contribute towards improving the teaching and learning of graphs of motion through an intervention drawing on pedagogy of multiliteracies. Furthermore, it was envisaged that this research study may contribute to our broader understanding of the use of semiotic teaching and learning support.

### **1.4 Theoretical framing**

The theories found to be useful for study are PoM (Cazden et al., 1996) and social constructivism (Vygotsky, 1978). PoM requires that teachers integrate technology-enhanced educational tools into their work (Ajayi, 2011) to bridge the gap between the traditional teaching strategies and the use of multiliteracies pedagogies in the teaching, taking into consideration the following four aspects:

- *Situated practice*
- *overt instruction*
- *critical framing*
- *transformed practice*

These four aspects of multiliteracies are further discussed in Chapter 2, (Section 2.3.1). The study focused on all four aspects as it was possible that they would complement each other during the intervention.

Mediation of learning, according to the social constructivist theory of Vygotsky (1978) is done through the use of signs or symbols of language to create the path between object and the learners thought. In this research study, mediation was attempted through the PoM intervention.

### 1.5 Definition of key concepts

Some of the key concepts in this study are defined below:

- **Kinematics:** The study of objects in motion. The terms used most frequently in kinematics are speed, velocity, acceleration, time, distance and displacement (Wadhwa, 2007).
- **Distance:** It is the length covered during the motion of an object. It is a scalar quantity and the international system of unit (SI unit) is the meter (Wadhwa, 2007).
- **Displacement:** It is the shortest distance between a moving objects' point of origin and the point of termination. It involves both direction and the magnitude and is thus a vector quantity. The SI unit is also the meter (Wadhwa, 2007).
- **Speed:** The average speed of an object is the ratio of the total distance travelled to the time interval. Speed is a scalar quantity. Average speed = total distance travelled / total time taken (Wadhwa, 2007).
- **Velocity:** This is the speed of an object in a specified direction. It is a vector quantity. And it is also referred to as the displacement per unit time. (Wadhwa, 2007).
- **Acceleration:** The acceleration of a moving object is the rate of change of velocity per unit time. It is a vector quantity and its SI unit is  $m/s^2$ . Sometimes the change in the velocity is due to increase in velocity that leads to negative acceleration called deceleration or retardation (Wadhwa, 2007).

- **Multiliteracies:** Refers to meanings made in ways that are increasingly multimodal and in which written–linguistic mode of meaning interfaces with visual, audio, gestural and spatial patterns of meaning (Cope and Kalantzis, 2000).
- **Pedagogy of multiliteracies (PoM):** A process that helps teachers blend and apply instructional process of multiliteracies in classroom for ensuring successful teaching and advancing students’ learning processes (Cazden et al., 1996).
- **Visual literacies:** The ability to assign meaning to visual field so it can be predictably interpreted. It includes charts, graphs, diagrams, maps, line graphs, drawings, photographs and icons (Rakes, 1999).
- **Graphicacy:** is a form of communication that utilises some form of symbolic language to convey information about spatial relationships (Wilmot, 1999).
- **Dispositions:** Disposition refers to a person’s particular behaviours in new learning contexts (Crick & Goldspink, 2014).
- **Prior knowledge:** Prior knowledge is defined as a multidimensional and hierarchical entity that is dynamic in nature and consists of different types of knowledge and skills (Hailikari, Katajavuori & Lindblom-Ylänne, 2008). Prior everyday knowledge refers to all the experiences learners have had throughout their lives.
- **Sense-making:** Is the process by which individuals interpret and reinterpret events which takes place and put them in a context to make sense of what is happening (Paull, Boudville & Sitlington, 2013). Newman, Morrison and Torzs, (1993) define scientific sense-making as a process in which theory and evidence are brought into coordination.

- **Mediation:** Mediation is defined as the use of certain tools within socially organized activity (Vygotsky, 1978).
- **Critical framing:** is an aspect of PoM that meant to guide students to derive their own meanings from classroom activities, which encourages them to think, understand, observe, interpret, negotiate and apply their ideas in problem solving (Biswas, 2014).
- **Transformed practice:** an aspect of PoM that encourages learners to connect their learning experiences with their daily classroom tasks, engaging them in applying what they have learned to solve real problems (Biswas, 2014).
- **Situated practice:** an aspect of PoM that suggest using students' life experiences to create meaningful classroom activities within a community of learners (Cazden et al., 1996).
- **Overt instruction:** an aspect of PoM that help learners to focus on important features and gain experiences that allow them to understand explanations of different learning modes (Cazden et al., 1996).

## 1.6 Thesis outline

**Chapter One** outlined the context of my study. It introduced the goal of my research study and presented the background of my study, with reference to international and national contexts including the NSSC national examiners reports. The rationale of the study is highlighted.

**Chapter Two** is the Literature Review of my study. The chapter also examines the theoretical framework of my study - pedagogy of multiliteracies, and social constructivism.

**Chapter Three** describes the research design that guided and shape the research process. It discusses the paradigm, methodology, research goals and questions, research site and sampling, the data gathering techniques, how data are prepared and analysed, validity,

ethical consideration and the limitations of the study. The chapter include literature relevant to the above elements for informing the data collection, preparation and analysis processes towards answering the research questions.

**Chapter Four** consist of data presentation, interpretation and discussion of findings. The research questions, themes related to answering them, and existing literature are used to construct this chapter. The themes are consolidated to form analytical statements.

**Chapter Five** contains conclusion and the research recommendations following from the analytical statements. It provides a summary of the research process

## **1.7 Conclusion**

This chapter outlined some literature which revealed that the topic of graphs of motion is challenging and that Physics learners often demonstrate difficulties answering questions related to it. It presented the rationale for my undertaking a study exploring the influence of a PoM approach on grade 11 Physical Sciences learners sense making and dispositions towards graphs of motion. The chapter also provided definitions for keywords, and a brief outline of the thesis chapters. In the next chapter, a review of some of the literature that is relevant to the study is discussed.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

The goal of this study is to explore the influence of Pedagogy of Multiliteracies (PoM) approach on the Grade 11 Physical Sciences learners' sense making and dispositions towards graphs of motion. This chapter presents a discussion of literature that is relevant to my study. This includes literature on visual literacy and graphicacy, kinematic graphs, prior knowledge, sense making and dispositions. Additionally, the theoretical frameworks, PoM and social constructivism will be discussed. This chapter ends with concluding remarks.

#### **2.2 Literature review**

##### **2.2.1 Curriculum expectations**

The Namibia, National Curriculum for Basic Education (NCBE, 2010) is the official policy for teaching, learning, and assessment and gives direction to teachers for planning, organising and implementing teaching and learning. Its purpose is to provide a coherent and concise framework in order to ensure that there is consistency in the delivery of the curriculum in schools and classrooms (ibid). Ever since Namibia's independence in 1990, the preparation for a knowledge based society has shown a preference for learner-centred education, which deals with learner-centred pedagogy and is guided by the principles of social constructivism transformative pedagogy, democratic education, conceptual learning, integration of knowledge, and meaning making and reflective practice (Dahlström, 1999).

According to Kasandaa, Lubben, Gaoseba, Kandjeo-Marengaa, Kapendaa and Campbell (2005) everyday contexts are used to allow learners to take control over their own learning. This is supported by Lubben, Campbell, and Dlamini (1996) who found out that using a context-based approach increased learner's participation in class and helped in determining what is to be learned. Additionally, the curriculum highlights that knowledge is not learnt for its own sake, but must always lead to new understanding, new skills and the creation of new knowledge (NCBE, 2010). At each step of the way, learners must show how competent they are in what they understand and can do.

The national curriculum describes the competencies which learners should attain, so that teachers know exactly what to teach and assess in order to be sure that the learners are progressing and achieving (NCBE, 2010). In a learner-centred social constructivist approach, teaching emphasises the varied processes and learning experiences (such as becoming literate in various semiotic modes such as the visual mode) needed for the creation of knowledge, rather than relying predominantly on transmission by the teacher.

## **2.2.2 Visual Literacy and Graphicacy**

### **2.2.2.1 Visual literacy**

Visual literacy is defined by Rakes (1999) as the ability to assign meaning to the visual field so it can be predictably interpreted. Visuals typically include charts, graphs, diagrams, maps, line graphs, drawings, photographs and icons. Visual literacy is about the ability to interpret visual messages accurately and to create visual messages effectively. Visuals provide rich information that both reinforces and supplements verbal content (Rakes, 1999). The ability to read, interpret and construct graphic displays is of growing importance in an increasingly visual world as students are exposed to electronic texts which rely heavily on graphical interfaces and graphic aids (ibid). It is thus clear why students need to develop the visual literacy skills necessary to use and learn from visual images.

Visual literacy is an important aspect of a multiliteracies approach, which links acquisition of literacy to academic achievement (Kitson, Fletcher & Kearney, 2007). After conceptualizing new literacies in the framework of multiliteracies there is now a need to include them in science teaching and learning. This can be done through the available semiotic systems to afford learners opportunities to develop shared understanding of visual texts and how they work (ibid). Abersêk (2008) emphasises that the use of visual literacy in teaching and learning also enables students to acquire the ability to understand how visual media produce meanings. The goals of visual literacy contribute to developing literate learners who are able to read, write, listen, talk, analyze, evaluate and learn through the use of multimedia (ibid).

According to Abersêk (2008) the ability to perceive, understand and evaluate visual data is an essential part of visual literacies. This is further supported by The International Visual Literacy Association (IVLA) which suggests that visual literacy includes the following:

- A group of competencies a human being develop by seeing and at the same time having and integrating other sensory experiences.
- The learned ability to interpret the communication of visual symbols (images), and to create messages using visual symbols.
- The ability to translate visual images into verbal language and vice versa.
- The ability to search for and evaluate visual information in visual media. (IVLA, 1989).

Visual literacy involves working with artifacts, images, and drawings that represent an event or an idea. In this context visual literacy can make most sense when defined as knowing and understanding visual texts that are part of the world of knowing and learning. Abersêk (2008) emphasizes that visual literacy is something learned, by developing the ability to understand and produce visual-language messages and to understand and produce visual language in information and explications in natural science texts.

According to Abersêk (2008) the use of visual images and meanings play a number of important roles for interpretation of math in science. These includes: helping to guide problem solution strategies, providing metacognitive warnings to facilitate error checking, and providing reasons to reject a particular mathematical model. Furthermore, Abersêk (2008) accentuates that new literacies involves the use of symbols to explain, introduce a part of nature, demonstrate a theory, or support a definition. Graphics use symbolic representations, and can be combined innovatively with simulation, sound, and music to communicate meaning about ideas, content, and concepts.

#### **2.2.2.2 Graphicacy**

Graphicacy is a form of communication that utilizes some form of symbolic language to convey information about spatial relationships (Wilmot, 1999). Graphical representation include maps, photographs, pictures, diagrams, sketches, posters and graphs. Graphs are a form of visuals used broadly in science classrooms, especially in the Physics component where they are taught in the topic of kinematics. Gillan and Lewis, (1994) add that graphs use spatial characteristics (e.g., height or length) to represent quantity.

According to Wilmot (1999), graphicacy requires the “creator or reader of graphic language to possess conceptual knowledge of the phenomenon represented in graphic representation as well as spatial perceptual abilities and an understanding of spatial concepts” (p.91). She further highlighted that it requires practical skills of being able to create graphic forms to communicate information to others (ibid). Zucker, Kay and Staudt (2003) elucidate that, graphs are commonly used in scientific journal articles, science textbooks, and in science classrooms. Compared to tables of numbers, or text, graphs summarize a larger quantity of information in a compact manner (ibid). Likewise, graphs are able to represent continuous change and co-variation visually in ways that tables cannot. Knowing that graphs communicate data and relationships so economically, scientists, mathematicians, and others who need to represent relationships between or among variables use them often. There is therefore a need for science teachers such as myself, to mediate the sense making of graphs and other visual representations for students.

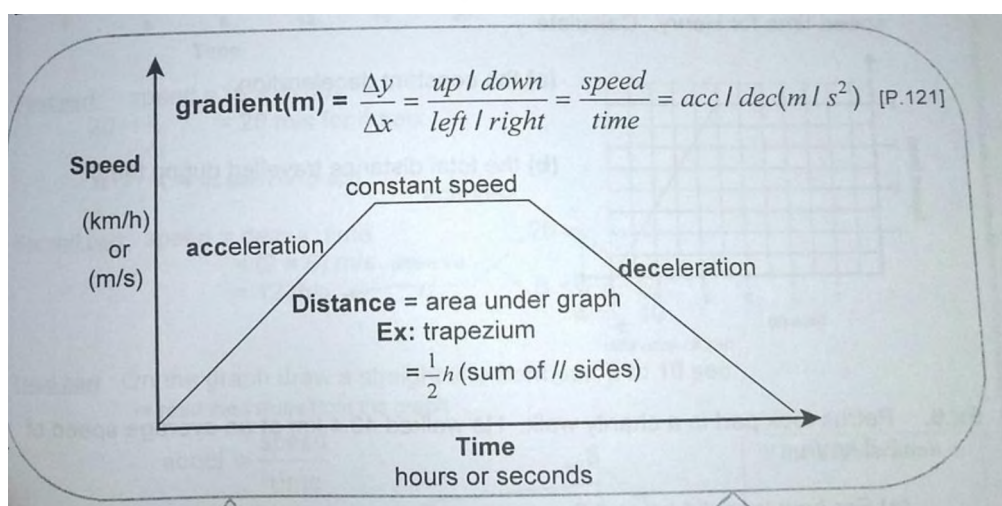
Zucker et al., (2003) mention that understanding graphs is not a mental ability to be mastered by students, but in fact a skill that is learned through training. Just like learning how to speak, read and write, students need to frequently explore, construct and explain graphs in order to learn how to use them well (Monk, 2003). Anagnostopoulou, Hatzinikita and Christidou (2015) reveals that graphs can bridge the gap between everyday knowledge that is based on oral description and scientific formalism transferred by mathematical formulas resulting in them being used as tools for knowledge transfer. Although this is the case, Lavertya and Kortemeyerb (2012) stress that instructors seem to be failing learners when it comes to educating them on the use and understanding of graphs. Learners lack understanding of the subject matter behind them, fail to understand the connections between graphs and the real world, and have difficulties in reading and interpreting graphs (ibid).

Friel, Curcio and Brigh (2001), emphasize that to interpret graphs, one can look for relationships among specifiers in a graph or between a specifier and a labeled axis. They went further to state that extrapolation and interpolation, which are considered to be extensions of interpretation, require stating not only the essence of the communication but also identifying some of the consequences. In working with graphs, one could extrapolate or interpolate by noting trends perceived in data or by specifying implications (ibid).

Graphing represents a key symbol system for scientific communication. Beichner (1994) asserts that graphical representations in science is a way of improving learners' science learning. They have a broad use in science classrooms because of the following reasons

- Graphs represent a lot of information and they show the relationship between variables
- There are many formulas in physics regarding motion of moving objects which symbolise abstract representations.

The figure below shows different parts of the speed versus time graph as well as some examples of formulas used in calculations.



**Figure 1: Speed versus time graph** (Source: D'Emiljo, 2012)

Such formulas can be represented using graphs e.g. in kinematics the relationship between speed and time can be represented in a speed versus time graphs. Using graphs can therefore be an alternative to the use of abstract formulas, or at least formulas can be used along with graphical representations to facilitate learners understanding. Additionally, graphs can present the same amount of information that long texts can presents. Graphicacy is based on specific data of what is presented and it is expected to be the same for everyone presenting a similar graph.

The most compelling evidence that the skill of graphing is a challenge to learners, is highlighted by (DNEA, 2008). This is also evidenced in the 2011 examiner's report (DNEA,

2011) where it is indicated that learners have a problem of identifying the gradient on the particular graph that represents the acceleration. As a result, learners could not find the resultant force from the average velocity as well as the average acceleration figures (DNEA, 2008). In the same manner, Lavertya and Kortemeyerb, (2012) noted that students usually express these kinds of errors when they interpret kinematic graphs.

### **2.2.3 Kinematic graphs**

In physics, the ability to work with graphs is important because graphical representations allow larger trends to be more easily found and understood while keeping smaller details visible (Lavertya & Kortemeyerb, 2012). In outlining kinematic graphs, Beichner (1994) points out that they have position, speed, velocity or acceleration as the ordinate (dependent or y-axis variable) and time as the abscissa (independent or x-axis variable). Due to the range of possible graphs, learners find it difficult to differentiate the meanings of distance, displacement, speed, velocity and acceleration versus time graphs.

The ability to work comfortably with graphs is regarded as a basic skill of scientists (Beichner, 1994). Line graph construction and interpretation are very important because they are an integral part of experimentation of the heart of science (ibid). The use of graphs is therefore essential in kinematics because kinematics graphs shows the relationships between the variables. For example, an acceleration versus time graph shows the change in velocity for a certain time period. Using kinematic graphs may help students to improve their problem solving capabilities. Graphs can also facilitate students understanding and may contribute to their learning but students need to have some prerequisite skills to understand kinematic graphs (Lavertya & Kortemeyerb, 2012).

According to his study on learners understanding of kinematic graphs, Beichner (1994) points out that many learner's produce incorrect velocity vs time graphs covered by a moving bicycle. Beichner (1994) points out some difficulties that students have when they use graphs in kinematics. He conducted a study with high school science learners and found that students confuse the slope and area in kinematics graphs (ibid). He stated that students were able to find distance using the formula ( $s = v / t$ , where  $s$  represents distance covered,  $v$  represents speed and  $t$  represents time taken) but they had difficulties in realising that the area under the curve of a speed versus time graph also represent the distance (ibid). Students

usually do not know when to use the slope or area when interpreting a particular graph. In most cases, they read values directly off the axes and directly assign them to the slope.

The figure below shows a distance versus time graph of different stages in someone's motion, the meaning of the slope/gradient and how to calculate it.

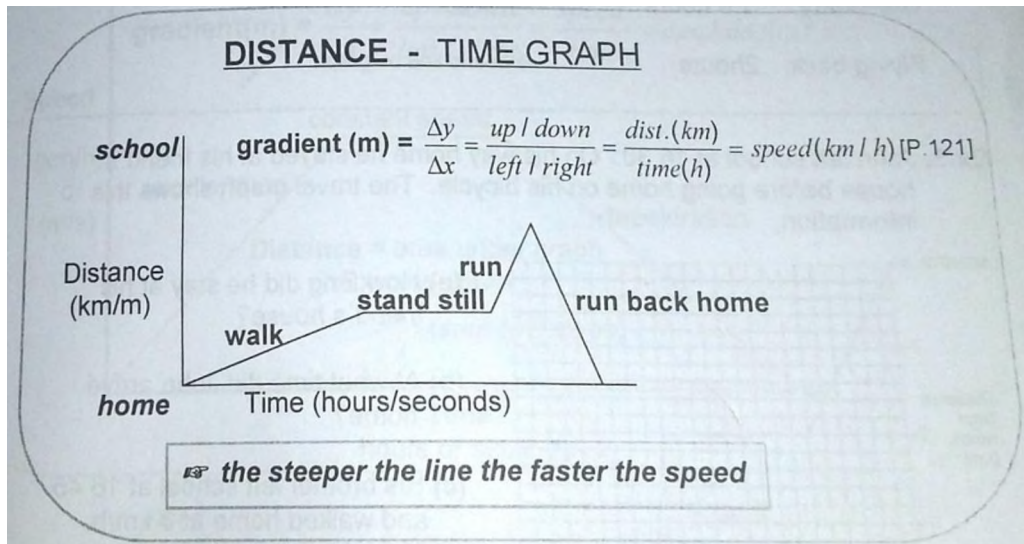


Figure 2. Distance versus time graph (Source: D'Emiljo, 2012)

The figure below shows velocity versus time graphs for uniform and non-uniform acceleration.

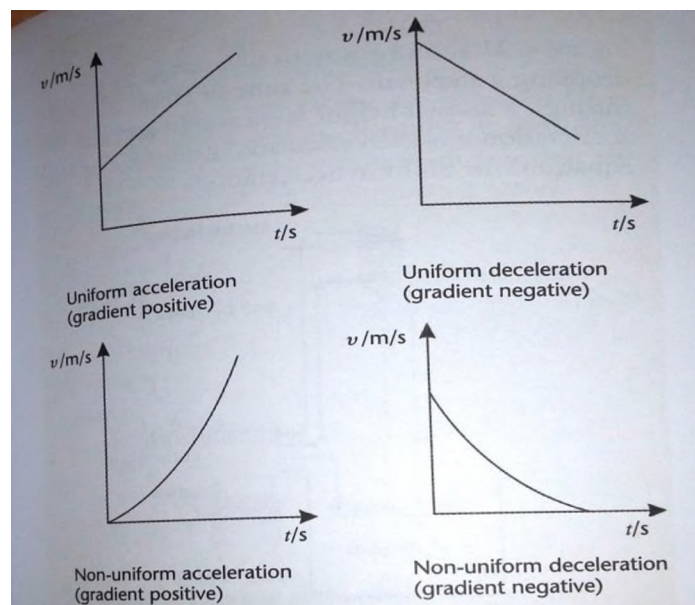


Figure 3: Velocity versus time graphs (Source: Dube, Ndlovu, Khalieli, Molapo, Jeoffreys, Goldon & Odara, 2011)

Beichner (1996) indicates that if students do not have a clear understanding of using slope and area, then they cannot interpret a graph correctly and they cannot make connections between graphs. For example, if a velocity versus time graph is given, students need to calculate the slope to get the acceleration and as a result, they need to know what slope, height and area represent in a graph to be able to separate them from each other (ibid).

Figure 4 shows the meaning of the area on velocity versus time graphs.

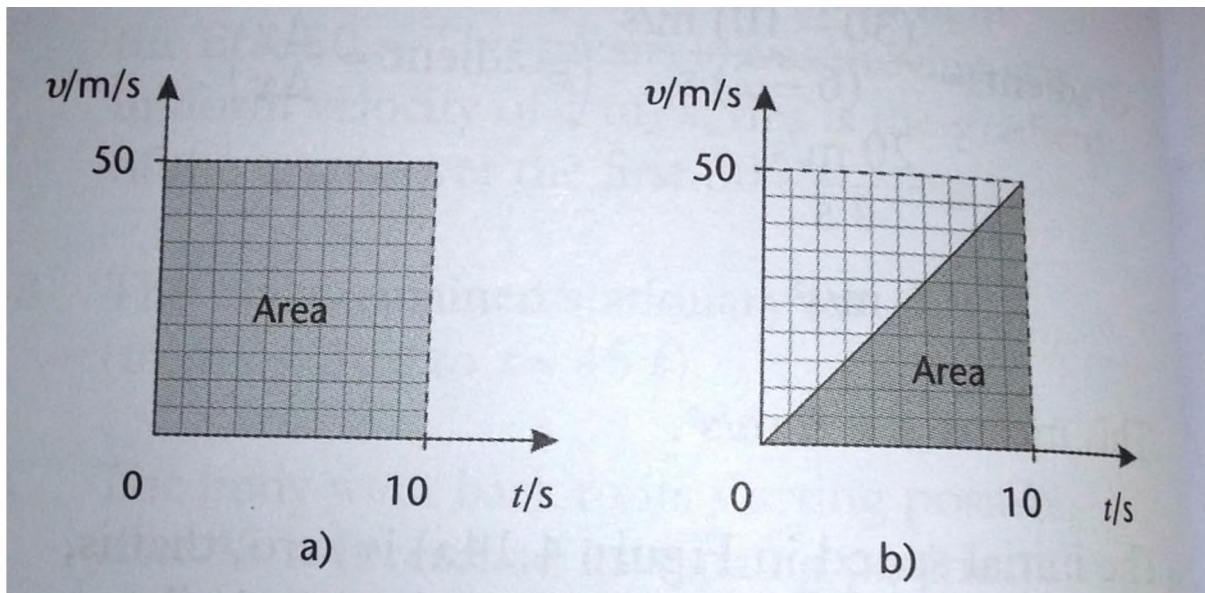


Figure 4: **Graphs indicating area under a velocity versus time graph = displacement**

(Source: Dube et al., 2011)

Berg and Phillips, (1994), Beichner (1994) and Trumper, (1997) accentuate that some students sometimes commit the “graph as a picture” error. When students interpret a graph as an actual picture, they do not think about the variables represented on each axis. Following the same line of reasoning, Beichner (1994) accentuate that graphs are often considered as forms of photographic-like replication of motion of the situation. They are often not understood to be an abstract mathematical representation but rather a concrete duplication of the motion event.

Brasell (1987) found out that students confuse distance versus time and velocity versus time graphs. The presentation of the two graphs might look similar but the information they presented are quite different. This is very common and may lead to misunderstanding of the relationship between the variables and kinematic graphs (Beichner, 1994). For example,

while a line parallel to the time axis in a distance time graph means there is no motion, in a velocity time graph it means constant velocity. Graphs in the context of kinematics, require an understanding of basic graphing concepts and skills often planned into earlier levels of curricular such that they become a part of learners knowledge prior to them encountering kinematics.

#### **2.2.4 Prior knowledge**

Prior knowledge is defined as a multidimensional and hierarchical entity that is dynamic in nature and consists of different types of knowledge and skills (Hailikari et al., 2008). According to Vygotsky (1978), everyday ideas or prior everyday knowledge become more academic or scientific over time when given assistance in both formal and informal settings. Prior everyday knowledge refers to all the experiences learners have had throughout their lives. It comes from both learning and general life experiences, being a product of how learners put new and old ideas together. Everyday life experiences may provide learners with numerous opportunities for observing and interacting with objects in motion. For example watching a baseball game, driving a car and even dropping a pencil involves encounters with moving objects. Presumably then, everyone has some sort of knowledge about motion. However, their prior experiences may lead only to the acquisition of concrete facts about the behaviour of specific object in specific situations e.g. when a moving ball strikes a stationary object, the moving ball often stops.

According to Hailikari et al., (2008), trying to learn something without having adequate prior knowledge or, worse, having misconceptions, may result in rote memorization. They further highlighted that this type of surface learning may occur if students cannot relate the new knowledge to their existing knowledge frameworks (ibid). Likewise, learners who have low prior knowledge might have difficulties when they use graphical displays (Behzat-Bektasli, 2006). Therefore, there is a need to facilitate learning by designing graphical displays that can help these learners perceive the presented information.

In their study conducted in Finland on prior knowledge, Hailikari et al., (2008) points out that a common problem faced by instructors is that students lack important prior knowledge and skills needed when they enter the more advanced courses in their curriculum. This is not only a challenge to instructors but it is also a major problem to students in schools as far as the

teaching and learning process is concerned. Learners should make connections between their day to day experiences of motion, for example when seeing a car, truck or a bicycle moving at a constant velocity or changing speed or acceleration. Mukwambo (2012) argued that if learner's prior everyday knowledge and experiences are considered during science lessons, learners will develop interest in science – this is important as it highlights the link between cognitive (sense-making) and affective (dispositional) aspects of science learning. Similarly, when learning graphical skills on kinematic graphs, learners do not only need to draw on the teachers' knowledge but the teacher also need to consider learners' prior everyday knowledge.

However, the literature reveals some contradictions around integrating prior knowledge to enhance learning in science classrooms. Learning distance versus time, displacement versus time, speed versus time, velocity versus time and acceleration versus time graphs without considering prior everyday knowledge might result in learners acquiring incorrect meaning and understanding leading to misconceptions on graphing. On the other hand, prior knowledge held by learners may include misconceptions that interfere with learning, and need to be replaced with correct conceptions (Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001).

Warren et al, (2001) argue that misconceptions about motion, arise from students' prior learning - often from their day-to-day interaction with the physical world. So, everyday experience is also viewed as a primary source of the educational problem (everyday explanations not always being scientific) and not only an aspect of the solution to address this problem (contextualizing science in the everyday to enhance science learning). If everyday experience is not addressed it may result in learners demonstrating incorrect scientific understanding when solving problems and answering examination questions related to kinematic graphs. Beichner (1994) is of the opinion that learners who have low prior knowledge have difficulties when they use graphical displays.

A common misinterpretation held by learners is that a horizontal line on kinematics graphs means that the object is at rest (Ainsworth, 2008). Ainsworth (2008) further added that, if learners can see a moving motorcycle at the same time as the velocity-time graph, then it

might help them understand that a horizontal line on a graph means uniform motion rather than no motion. This example reveals the potential of employing a PoM intervention, as is the case in this study. The PoM intervention being investigated in this research, will include the use of videos of objects in motion for teaching kinematic graphs to enhance learners' sense making in the topic.

### **2.2.5 Sense making**

Science education aims to transform learners thought to make sense of what they are learning. Newman, Morrison and Torzs, (1993) define scientific sense-making as a process in which theory and evidence are brought into coordination. They explain it in more detail by saying that it is a dynamic process in which there is a movement and development of ideas as new evidence is introduced and as theoretical concepts are refined and changed (ibid). Audet, Hickman and Dobrynina (1996) highlighted that this process promote student understanding when teachers and students conduct scientific conversations in which they frame essential questions, develop structures for inquiry, and integrate theory with evidence. This includes students detecting patterns, asking focusing questions, seeking explanations, distinguishes theory and evidence and using tools to construct meanings (ibid).

By themselves becoming part of a phenomenon, students make sense of situations by gaining direct experiential awareness about how the natural world operates (Dede, Salzman & Loftin, 1996). When explaining in-the-moment, students gesture in ways that help them to predict, revise, and coordinate elements in a model. According to Singer, Radinsky, Goldman, Oliva, Allende-Pellot, Liceaga, Sacay, Alamar, Trigueros & Rodriguez (2006), to co-construct the meanings of abstract science concepts, complex datasets, and events, there is a need to use multiple modes of communication. These may include visual, gestural, and verbal representations of the phenomena being studied (ibid). By working with visual data, students used gesture during learning to make sense of their understanding. Furthermore, Dede et al, (1996) highlight that good instructional design can make the aspects of virtual environments useful in understanding scientific principles most salient to learners' senses.

Teachers on the other hand frame questions, provide structures, coordinate theory and anchor discussion in students experience for them to make sense of graphs of motion when solving such problems (Audet et al, 1996). Koendinger, Corbett and Perfetti, (2012) show

strong agreement by advocating that sense-making is an explicit process that allows students an attempt to understand or reason when verbally mediated with activities such as comprehension of verbal descriptions, explanation-based learning and scientific discovery (ibid). Sense making can thus be conceived of as coordinating non-verbal with verbal forms of knowledge that will improve understanding, and possibly lead to a change in learner's dispositions.

### **2.2.6 Learners' dispositions towards science**

Learner's dispositions towards science affects their learning of science. Different writers have provided different definitions of what dispositions are. According to Crick and Goldspink, (2014) dispositions refers to a person's particular behaviours in new learning contexts. It is about the measurement of how much a person believes they are able to change over time and how quickly they give up when faced with challenges or confusion in a learning situation. Katz (1988, in Carr and Claxton, 2002) define dispositions as a type of learning that is different from skills and knowledge. It can be thought of as behaviours of mind and the tendencies to respond to situations in certain ways. Additionally, Perkins (1995, cited in Carr & Claxton, 2002) described dispositions as the tendencies that lead us in one direction rather than another, within the freedom of action demonstrated by individuals. According to Gresalfi (2009), students' individual participation, small group work, and teacher intervention shape productive dispositions and learners' opportunity to learn. So, what students learn cannot be separated from how they learn it (ibid). She further suggested that teachers' classroom practices play an important role in student's dispositions.

In addition, Carr and Claxton (2002) states that the focus of education is shifting to a concern with the development of aptitude and attitudes that will equip young people to function well. They proposed indicators of assessing learners learning dispositions. These include resilience, playfulness and reciprocity which can be linked to Kilpatrick, Swafford and Findell's (2001) indicators on productive dispositions of sense making, seeing oneself as effective and being able to make connection to learner's world. These indicators make it possible for the teacher to observe whether learners' dispositions is changing or not (Carr & Claxton, 2002). However, Carr and Claxton (2002) acknowledge that "there is no clear agreement about what the 'key' learning dispositions might be" (p. 12).

Crick and Goldspink (2014), highlight that research into learning dispositions addresses the need for deep engagement in learning and for an approach to pedagogy that allowed the learner and their teachers to focus on improving the processes of learning and development. This is through enabling individuals to reflect on their approach to learning and to begin to navigate their own pathway through the curriculum rather than to depend on teacher direction (ibid). Additionally, Dewey (1933, in Blaiklock, 2008) recognized the importance of dispositions in addressing the gap between doing something and the desire to do it. Blaiklock (2008), further states that if a person is not prepared to be critically curious, then ‘teaching strategies’ enforced from outside are unlikely to lead that person to want get to the ‘bottom of something’, or find their truth.

Learning dispositions can be identified by focusing on a particular behavior. The table below shows the links between learning dispositions and behaviours (Carr, 1998).

**Table 2: Links between learning dispositions and behaviours (Carr, 1998)**

<b>Dispositions</b>	<b>Behaviours looked for</b>
Courage and curiosity	Taking an interest, belonging, exploration
Trust and playfulness	Being involved, well-being, belonging
Perseverance	Persisting with difficulties, challenge and uncertainty
Confidence	Expressing a point of view or feeling
Responsibility	Taking responsibility

According to Blaiklock (2008), the reason for selecting certain behaviours as indicative of certain dispositions is not always perfect and there are problems in interpreting what a named behaviour actually comprises. Obviously, teachers could be expected to diverge broadly in the understandings they apply when assessing each behavior (ibid).

Anku (1996) highlighted dispositions as a change in attitudes as a result of an intervention in a non-threatening classroom environment that is helping students develop concepts through a variety of activities that are related to real life experiences. According to Kurt and Temelli (2013), the concept of attitude is frequently used to define people and to explain their

behaviors. This includes an element of curiosity towards things, and this is not only determined by whether learning takes place, but also how it is achieved (ibid). In my study, learners constructing graphs of motion might increase their critical curiosity, meaning making and creativity as they are provided with a chance to learn from real physical representation (videos of objects in motion). If learners focus on improving and trying, they are more likely to feel comfortable making mistakes and revising their thinking over and over again. Borda (2007) is of the opinion that disposition may be considered as a way of facilitating one's cognitive understanding as opposed to operating separately from it.

## **2.3 Theoretical framework**

The theoretical orientation of this action research is drawn from PoM, (Cazden et al., 1996) and social constructivism (Vygotsky, 1978). Social constructivism and PoM might allow learners to change their attitudes through effective discussions and class activities involving different semiotic modes, enhancing the construction of kinematic knowledge. These might help learners to move from a common sense to scientific understanding (Hodson & Hodson, 1998) by supporting teachers to shape learner's sense making and dispositions towards the inclusion of scientific concepts (ibid).

### **2.3.1 Pedagogy of multiliteracies (PoM)**

Pedagogy of multiliteracies (PoM) is a process that helps teachers blend and apply instructional process of multiliteracies in classroom for ensuring successful teaching and advancing students learning processes (Cazden et al., 1996). The approach prepares learners to cope with realities of the technological world (ibid). It requires that teachers integrate technology-enhanced educational tools into their work (Ajayi, 2011) to bridge the gap between the traditional teaching strategies and the use of multiliteracies pedagogies in the teaching of science.

The use of multiliteracies are tailored to develop and implement strategies to improve pedagogical practices (Biswas, 2014). Newman (2002, in Biswas, 2014), as well as Cope and Kalantzis (2009) highlight situated practice (leading students towards meaningful learning by integrating primary knowledge), overt instruction (introducing learners to different learning modes), critical framing (encouraging learners to create their own meanings) and

transforming practice (engaging learners in applying what they have learned to solve real problems) as aspects of multiliteracies.

My study will focus on all four aspects of PoM as they may function together in helping learners to shift from everyday common sense to scientific sense making possibly influencing their disposition to the topic positively). The four aspects will now be described in more detail.

### **2.3.1.1 Situated practice**

Situated practice as conceived in PoM, is constituted by immersion in meaningful practices within a community of learners who are capable of playing multiple and different roles based on their background and their experiences (Cazden et al., 1996). The meaningful practice is achieved through the involvement of people who have mastered certain experiences in guiding learners previous and current experiences (ibid). Cazden et al., (1996) are of the view that situated practice ensures meaningful learning is practiced in the classroom. Learners' interactions with classmates allow them to practice and understand the value of classroom activities within a community of learners with the help of the teacher (ibid). With situated practice as an aspect of pedagogy, evaluation of the learning process is used for development, for guiding learners to the experience and the assistance they need to develop, and not necessarily for judging ability or achievement.

### **2.3.1.2 Overt instruction**

Cazden et al., (1996) highlighted that overt instruction helps learners focus on important features and gain experiences that allow them to understand systematically and analytically, explanation of different modes of meaning. The main goal of overt instruction is to create conscious awareness and control of what the learners are learning over what is being practiced. (ibid). Furthermore, Cazden et al., (1996) explain that overt instruction includes all the active interventions on the part of the teacher and other experts that scaffold learning activities which focus the learner on the important features of their experiences and activities and allow them to gain explicit information when it can most usefully guide the practice and build on what the learners already know. The intervention create different meanings in the learning process as learners will be able to link physical representations learned and solve graphical problems.

In overt instruction, students are allowed to accomplish tasks on their own when they come to conscious awareness of what the teacher has presented and interpret the task and its relation to what is being learned (Cazden et al., 1996). This aspect of pedagogy should be developmental as in the case of situated practice (ibid).

### **2.3.1.3 Critical framing**

According to Cazden et al., (1996) critical framing is about helping learners frame their “growing mastery in practice (from situated practice and conscious control and understanding (overt instruction) in relation to the historical, social, cultural and value-centred relations of particular systems of knowledge and social practise” (p.86). The role of the teacher in critical framing is to help learners denaturalize and make strange again what they have learned during the lesson and also what they have mastered (ibid). Through this, learners can gain the necessary theoretical distance from what they have learned, critique it constructively, creatively extend and apply it and eventually innovate on their own (Cazden et al., 1996). This further represents one sort of learning transfer and one area where evaluation can begin to assess learners and the learning process in which they have been operating (ibid). Critical framing might guide learners to derive their own meanings from classroom activities, which might encourage them to think, understand, observe, interpret, negotiate and apply their ideas (Evans, 2005 in Biswas, 2014) when solving graph of motion problems, in this study.

Learners may improve their graphical interpretation skills with thoughtful understanding. The teaching intervention might help them realise, comprehend and respect diverse knowledge in order for them to communicate meaningful ideas. When watching a video of an object in motion, they will be listening and speaking about things that require them to observe the moving object, interact and at the same time consider what they are seeing on the screen mathematically and graphically. So the text that learners write or read will rely on processing several modes of text simultaneously in order to construct meaning (Anstey & Bull, 2006).

### **2.3.1.4 Transformed practice**

Cazden et al., (1996) highlighted that there is a need to return to where learners began, to situate practice, but now re-practice, where theory becomes reflective practice. Besides that, students with their teachers need to develop ways in which they can demonstrate how they can design and carry out in a reflective manner, new practices embedded in their own goals and values (ibid). Biswas, (2014) highlighted that information is transmitted into knowledge

and fulfils the learners learning styles and needs. These then encourage them to comprehend the learning process (Ajayi, 2011). According to Cazden et al., (1996), there is transfer in meaning making practice which puts the transformed meaning to work in other context.

Bull and Anstey (2006) highlighted that PoM changed learner's interaction by encouraging them to take more responsibility for their learning, shifting the locus of control from teachers to themselves and spurring them to engage in more substantive conversations. Furthermore, students should be able to show that they can implement understanding acquired through overt instruction and critical framing in practices that help them simultaneously to apply and revise what they have learned (Cazden et al., 1996). Transformed practice encourage students to connect their learning experiences with what they have learned in class.

## **2.4 Social constructivism**

The origins of constructivism are believed to date back to the time of Socrates, who claimed that teachers and learners should talk with each other and interpret and construct the hidden knowledge by asking questions (Hilav 1990, cited in Erdem, 2013). According to the constructivists, learning is a process of constructing meaning and it is how people make sense of their own experience (Amineh & Asl, 2015). Mvududu and Thiel-Burgess (2012) state that constructivism is an approach that can be used to probe for learners' level of understanding and to show that their understanding can increase and change towards higher levels of thinking. According to Amineh and Asl (2015), constructivism refers to the how of learning and thinking. It describes the way that the students can make sense of the material and also how the materials can be taught effectively (ibid). Additionally, Fosnot (1989), defines constructivism according to the following four principles which are related and can be linked to the use of prior everyday knowledge and the PoM intervention respectively:

- learning depends on what learners already know,
- new ideas occur as learners adapt and change their old ideas

These are related to prior everyday knowledge and experience that need to be considered during science teaching and learning and they are discussed earlier in Section 2.2.4.

- Learning involves acquiring, modifying and discovering new and existing ideas rather than automatically accumulating a series of facts. This is related to critical framing, an aspect of PoM intervention part that is explained in Section 2.3.1.3 above.

Critical framing highlights the issue of critiquing constructively what learners have learned, extending it creatively, applying it and eventually innovating independently.

- Meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with the old ideas. This is linked to the transfer in meaning making practice which puts the transformed meaning to work in other context, an aspect of PoM highlighted in Section 2.3.1.4.

Furthermore, Christie (2005) point out that from a constructivists point of view, learning is both an active process and a personal representation of the world. It is constructed from the experience and is modified through different experiences (ibid). Amineh and Asli (2015) added that problem solving and understanding, authentic tasks, experiences, collaboration, and assessment are among other important factors in this theory of learning.

Social constructivism is an aspect of constructivism. It is a theory of learning, which claims that learners socially construct knowledge rather than receive and store knowledge transmitted by the teacher (Ben-Ari, 2003). It is a very complex approach that deals with social interaction, and mediation. Vygotsky (1978) suggested that more knowledgeable others help learners by scaffolding them intellectually and this will help them to carry out challenging tasks when they are alone. With social constructivism as a theoretical framework, the teacher considers what students know, mediates new learning and allow the students to put their knowledge into practice. The concepts of mediation will now be explored.

### **Mediation of learning**

Mediation is defined as the use of certain tools within socially organized activity (Vygotsky, 1978). Vygotsky's theory of constructivism supports that the use of activity mediators provides a way in which people are able to interact with nature. Lopes, Cravino, Branco, Saraiva and Silva (2008) accentuate that during mediation, the teacher should try identify the students' prior knowledge, competences and worldview, and systematically check the students' learning demand in their learning process. Thus, there is a need to take into account the concept of mediation and the active position of the child in learning (Vygotsky, 1978). Furthermore, Amineh and Asli (2015) states that constructivists believes that learner's initial conceptions of knowledge are derived from a meaning-making search in which learners construct individual interpretations of their experiences. The learners' constructions during

the examination, questioning and analyzing of tasks and experiences yield knowledge whose correspondence to external reality may have little truth (ibid).

Additionally, when mediating literate practices, students draw from different experiences to make meaning (Bull & Anstey, 2006). This includes the lifeworld (everything that exist around the school) and the school based world (ibid). Mediation is viewed as most productive when the learner is ready to learn new material, while simultaneously being offered material that encourages more complex ways of talking, acting, and understanding (Vygotsky, 1978). The learner's literacy identity when mediating text is represented by the intersection of knowledge and experience with literacy from his or her school based world and lifeworld. Vygotsky (1978) states that cognitive growth occurs first on a social level, and then within an individual. To make sense of others and construct knowledge on a social level allow learners to relate themselves to circumstances (ibid). Roth (2011) also states that the roots of individuals' knowledge are found in their interactions with their surroundings and other people before their knowledge is internalized.

In context, the intervention on PoM might assist learners to construct knowledge that is based on reality and learning. Vygotsky (1978) argues that the path between object and thought is mediated by other people through the use of signs or the symbols of language. Furthermore, he certainly supported collaboration in practice as a foundation of learning supporting the PoM notion that certain forms of overt Instruction are needed to supplement acquisition of knowledge if teachers want learners to gain conscious awareness and control of what they acquired (ibid). Mediation of learning through visual literacies/semiotic modes or signs will play an important role in my PoM intervention. The intervention will be designed in a way that might allow learners to make sense through restructuring their understanding by first seeing where, how and why they are failing to solve kinematic problems. Through this, learner's ideas might be modified and refined – possibly shaped towards a shared set that makes discourse and collaborative action possible (Millar, 2004).

In social constructivist classrooms, students are actively involved, the environment is self-directed, and interaction becomes crucial in learning (Gray, 1997). Gray (1997) suggest that with the importance given to collaboration, knowledge, and creativity through social

constructivism learners can start learning in pair work, group work, and teamwork, and later make their own contributions to the world of knowledge. Overt instruction, situated practice, critical framing and transformed practice (aspects of pedagogy of multiliteracies) may together mediate learning. Learners might be able to collaborate by sharing their thoughts while engaging with different semiotic modes (texts and videos), possibly overcoming limitations that are associated with the traditional learning approach thereby providing more equal access to all the learners.

## **2.5 Conclusion**

In this chapter, I reviewed a range of literature related to my study. The discussion of the literature is based on the Namibian curriculum expectations, keywords in the study and the conceptual and the theoretical frameworks that I used to inform this study. I also briefly discussed kinematic graphs in relation to pedagogy of multiliteracies and social constructivism and how these theories inform teaching and learning of graphs of motion. In the next chapter I present the research design for this study.

## CHAPTER 3

### RESEARCH DESIGN

#### 3.1 Introduction

The goal of this study is to explore the influence of PoM approach on the Grade 11 Physical Sciences learners' sense making and dispositions towards graphs of motion. This chapter presents a discussion of the research design that is employed in my study. The research paradigm, methodology, research goal and questions are highlighted. The chapter also discusses the research site and sampling, data gathering techniques such as pre-test, stimulated recall interviews, observation, post-test and learners' reflections. The discussion of data gathering techniques give insights into how data were gathered and triangulated. This is followed by a discussion of data preparation, data analysis, validity, ethical issues and possible limitations to the study.

#### 3.2 Research paradigm

A research paradigm is the identification of the underlying basis used to construct and guide scientific investigation (Bogdan & Biklan, 1982; Guba & Lincoln, 1994). Bertram and Christiansen (2015) are of the views that research paradigm "represent a particular world view that defines, for the researchers who hold this view, what is acceptable to research and how this should be done" (p. 22). The paradigm adopted for this study is the interpretive paradigm.

The interpretive paradigm focuses on understanding the subjective world of human experience (Cohen et al., 2011). Creswell (2009) also states that interpretive paradigm is directed at understanding phenomenon from an individual's perspective, investigating interaction among individuals as well as the historical and cultural contexts which people inhabit. Individual concepts are elicited and understood through interaction between researchers and participants (Guba & Lincoln, 1994) and this is only possible if research participants are relied on as much as possible since they are the ones providing the data (Creswell, 2009).

Furthermore, Scotland (2012) is of the opinion that, interpretive methods yield insight and understandings of behaviour, they explain actions from the participant's standpoint, and do

not dominate the participants. In the situation of this study, this paradigm encompassed learners' making sense of their experiences of graphs of motion and possibly changing their dispositions towards graphs of motion in order to understand the science world.

According to Krauss (2005), many qualitative researchers believe that the best way to understand any phenomenon is to view it in its context. For them, the best way to understand what is going on is to become immersed in it (*ibid*). Qualitative methods refer to a broad class of empirical procedures designed to describe and interpret the experiences of research participants in a context-specific setting (Denzin & Lincoln, 2000). In general, qualitative research is based on a relativistic, constructivist ontology that posits that there is no objective reality in nature, looking only at one small portion of a reality that cannot be split or centralised (Krauss, 2005).

Additionally, Taylor and Bogdan, (1998) highlight that qualitative findings are generally presented in everyday language and often incorporate participants' own words to describe a psychological event, experience, or phenomenon. A qualitative approach to answering research questions is an empirical method in that it involve the collection, analysis, and interpretation of observations or data. The influence of the interpretive paradigm will thus be strongly evident as the subsequent sections of this chapter unfold.

### **3.3 Methodology**

Different approaches to research allow us to understand research situations differently and for different reasons (Deetz, 1996). The methodology chosen for a certain research study depends on what the researcher is trying to do rather than just a commitment to a particular paradigm (Cavaye, 1996) hence adopting the interpretive paradigm for this study. Methodology is defined by Crotty, (1998) as the strategy or plan of action which lies behind the choice and use of particular methods in a research study. It is thus concerned with why, what, from where, when and how data is collected and analysed (Scotland, 2012).

In my study, the methodology involves me researching my own teaching practice as a science teacher. Furthermore, the research focused on whether the PoM approach helps learners make sense of graphs of motion and whether or not their dispositions towards graphs of motion changed in the process. Thus, the methodology employed matches the particular

phenomenon of interest, as it should be (Krauss, 2005). The methodology is action research since it requires strongly integrating my research with my own practice.

### **3.3.1 Action research**

Kember, Ha, Lam, Lee, Ng, Yan and Yum (1997) states that action is used to develop theory from real teaching contexts, in attempting to improve the quality of teaching and learning. Similarly, Bertram and Christiansen (2015) defines action research as a research done by researchers on their own practice in order to increase self-awareness, to change practice or change a particular situation for the better (ibid). McNiff (2002, cited in Cohen et al., 2011) highlight that action research combines diagnosis, action and reflection. In the same vein, Bertram and Christiansen, (2015, p. 45) states that action research consists of a cycle of action and reflection and it consists of the following steps

- Step1: strategic planning
- Step 2: taking action and implementing the plan
- Step 3: observation, evaluation and self-evaluation
- Step 4: reflection on the process and making decision for the next cycle of action research

Also in agreement, Cohen et al, (2011) highlight that action research involves planning, acting, observing and reflecting which can help define issues, ideas and assumptions for someone as their work progresses. This study aims at exploring the influence of multiliteracies intervention on grade 11 Physical Science learners' sense making and dispositions towards graphs of motion.

According to Bertram and Christiansen (2015), action research study is based on the assumption that teachers know best what is happening in the classrooms and are therefore the best people to do classroom research. This action research study involves researching my own practice with the help of a critical friend. A critical friend was chosen on a basis that she is a professionally trained Mathematics and Science teacher at the school where I am teaching. She holds a Bachelor degree with honours from the University of Namibia. She has the experience of teaching Physical Sciences at the level of grade 11 and 12. A critical friend has a significant role to play in action research because he is regarded as a partner who can give advice and through working with the teacher researcher, will be an agent for teacher

development (Kember et al., 1997). Kember et al., (1997) further stated that the focus of the critical friend is mainly on supporting the insider-teacher by improving the quality of teaching and learning. This was done to “bridge the gap between theory and practice and recognise that the process of building knowledge is as important as the product that may come out of the research” (Bertram & Christiansen, 2015, p 45). This is seen as part of professional learning and development since it improves educational practices (ibid).

### **3.4 Research goal and questions**

#### **3.4.1 Research goal**

The goal of this research study was to explore the influence of the Pedagogy of Multiliteracies (PoM) approach on Namibian grade 11 Physical Sciences learners’ sense making and dispositions towards learning graphs of motion. The action research methodology entails me researching my own practice for professional development as a science teacher as well as the broader rationale mentioned earlier.

#### **3.4.2 Research questions**

##### **Main research question**

To achieve the above goal, the research question is

What is the influence of a pedagogy of multiliteracies teaching approach on Namibian grade 11 Physical Sciences learners’ sense making of, and dispositions towards graphs of motion?

##### **Research sub-questions**

In order to answer the main question, I explored the following sub-questions

1. What is the grade 11 Physical Science learners’ prior knowledge of and initial dispositions towards graphs of motion?
2. What factors enable/constrain learners’ sense making of graphs of motion when it is mediated using a pedagogy of multiliteracies approach?
3. How does the pedagogy of multiliteracies approach to teaching kinematic graphs influence learners’ dispositions towards learning graphs of motion?

### **3.5 Research site and sampling**

#### **3.5.1 Research site**

Cohen, et al. (2011), states that it is better to work with research participants who suit the research best. The goal of my study was to explore the influence of pedagogy of multiliteracies (PoM) on the Namibian grade 11 Physical Sciences learners sense making and dispositions towards graphs of motion. The research participants were thus my grade 11 Physical Sciences learners, meaning that the intervention process took place at *Collegiality* Secondary School (pseudonym), the school in which I teach. The school offers Physical Sciences from grade 8-12. There are six (6) grade 11 Physical Sciences class and the focus of my research study was one of those Grade 11 Physical Sciences class with 35 learners. I purposefully selected *Collegiality* Secondary School since it is within my reach as a teacher researcher. I sought voluntary participation of a grade 11 Physical Sciences class because graphs of motion is part of the Grade 11 Physical Sciences curriculum in Namibia.

#### **3.5.2 Sampling**

From the class of 35 grade 11 Physical Sciences learners mentioned earlier, a sample of 10 learners was selected purposively based on their test performance results and this made up part of the interview sample group. Cohen et al., (2011) describe purposive sampling as “a feature of qualitative research, where researcher hand-pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought” (p. 156). According to Bertram and Christiansen, (2015) the researcher makes specific choices about who to include in the sample. The sample of 10 learners specifically chosen to do the stimulated recall interviews was based on their performance in the pre-test paper. They were chosen based on the following categories: 3 learners who showed high level of understanding, 3 learners who showed average understanding and 4 learners who performed below average and showed lack of skills in kinematic graphs.

Thirty (30) grade 11 Physical Sciences learners completed the pre-test questions which were administered before the PoM intervention. These were the learners whose parents returned the informed consent letter and had agreed for their children to take part in the research study. However, only twenty-one (21) of those who completed the pre-test were available to attend the graphs of motion intervention and these are the ones who

participated in class activities, reflections and who have completed the post-test after the intervention with PoM. Because of this, the data analysed will only be from the learners that completed both the pre- and post-test and were part of the PoM intervention process.

### **3.6 Data gathering techniques**

Data to be used in this study was collected from the grade 11 Physical Sciences learners. I used document such as learners' pre-test and post-test scripts and reflections to collect the data used during the study. Stimulated recall interview based on the learners responses to the pre-test, and lesson observations were used to generate further data.

#### **3.6.1 Pre-test and post test**

To collect data, learners were tested before the intervention to ascertain their level of understanding and then again after the intervention (Bertram & Christiansen, 2015). A pre-test was used to determine the conceptual understanding of the grade 11 learners to ascertain their understanding of graphs of motion prior to my teaching the section. This was done to provide answers to research sub-question one and to inform the intervention. The intervention process was discussed with the critical friend in order to check the alignment with the grade 11 Physical Sciences Syllabus. During the intervention, learners were assigned graphs of motion activities which allowed them to work collaboratively with one another.

My critical friend read the activities to check the language used and whether the types of questions were at the learners level or not. The activities posed to the learners help in identifying factors that enable or constrains learners' sense making of graphs of motion when mediated with the PoM approach. After the intervention, learners were administered a post-test to in order to explore the influence of the intervention, or answering sub-question 3. (this was seen in a way the grade 11 learners answered the post test questions as compared to their initial responses from the pre-test thus I measured their disposition from their test responses, learners reflections were also used in the process to provide answers to research question 3)

#### **3.6.2 Stimulated recall interviews**

After administering the pre-test, a stimulated recall interview was conducted with the sample of ten (10) learners. A rationale of the choice of questions on stimulated recall interviews with the learners is attached on the appendices as Appendix F. The interviews helped me to get

detailed information on learners understanding and in identifying possible shifts in dispositions towards graphs of motion as they would not have been evident in the pre and post-test with their cognitive focus. The stimulated recall interviews also allowed me to get learners' views on the range of specific difficulties experienced when learning and solving graphs of motion problems. I found this necessary since it allowed me as a researcher to ask probing and clarifying questions and discuss research participants understanding with them as recommended by Bertram and Christiansen (2015). The stimulated recall interviews were guided by open-ended questions because that is what was required for answering the associated research question.

A stimulated recall interview is an introspective research procedure which uses audio recordings, video footage, photographs or other aids to assist research participants to recall their experience of an event during post-event interviews (Mackenzie & Kerr, 2012). Although it is stated that stimulated recall interviews uses videos, photographs or even audio, I used pre-test learners' transcripts as a stimulus to obtain deeper insights during the interviews in order to answer the first and second research questions. The stimulated recall interviews were audio recorded with the consent of the learners and transcribed for the information to be captured in full to facilitate qualitative analysis.

### **3.6.3 Intervention (Lesson presentation and observations)**

Observation means that the researcher observes what is actually taking place at the research site in order to obtain first hand data (Bertram & Christiansen, 2015). According to Cohen et al., (2011) "observation is very important because the researchers can look directly at what is taking place in *situ* rather than relying on second hand information" (p. 456). It is done to see things that the research participants might not talk about in the interviews. The intervention process was made up of six lessons and only four of them were observed and videotaped with permission from the research participants, since the first and the last lesson involved administering the pre and post-tests without any teaching taking place during these sessions. Observation was used to identify factors that enable or constrains learners understanding of graphs in motion and indicators of dispositions when mediated using PoM approach thereby answering research sub question 2 and 3 respectively.

### **Overview of lesson 1:**

This is the lesson where the pre-test was administered (Appendix E). The test was administered to the class of grade 11 Physical Sciences learners in order to find their initial sense making concerning the graphs of motion questions.

### **Overview of lesson 2:**

After the pre-test, I started with the first intervention lesson where the graphs of motion concepts were introduced. The lesson was strongly informed by the way the research participants had answered questions in the pre-test. Online 'You tube' graphs of motion videos were used to demonstrate and explain the differences between different kinematic concepts highlighted below.

- Video 1: Difference between distance and displacement (The Science Classroom, 2013)

The video showed the distance and displacement covered by a moving object and how to determine distance/displacement covered, including their units. The Science Classroom video (2013) on distance and displacement explains why distance is regarded as a scalar and displacement as a vector quantity.

- Video 2: Speed and its calculations (Bodhaguru, 2012)

Bodhaguru's (2012) video shows the difference between uniform and non-uniform speed. The video also shows the best way of differentiating these types of speed by looking at cars moving on a highway.

- Video 3 and 4: Difference between speed and velocity (SciHgg, 2013; IBDP physics, 2008)

The video of objects in motion showing the differences between speed and velocity in their simplest terms. The videos reporting the differences between speed and velocity in terms of their definitions and calculations was projected for the learners to watch. This was followed by the teacher intervening at some stages during the process to clarify verbally.

- A group discussion on the difference between speed and velocity was done soon after the explanation and before starting with the classwork on distance and displacement.

- A class group activity on the difference between distance and displacement as scalar and vector quantity was assigned to the learners to complete at the end of the lesson.

### **Overview of lesson 3:**

A summary of the previous lesson was provided, followed by learners watching videos on how to draw kinematics graphs.

- Summary of the previous lesson

Feedback on activity from the previous day was given to learners, followed by a summary of the previous lesson. Questions were asked to check whether learners could still recall what they were taught the previous day.

- Distance, displacement, speed, velocity and acceleration vs time graphs

Two videos were watched during lesson three and they showed how one can draw a graph of motion while observing an object that is in motion.

- Video 4: “the moving man”, a stimulation that was created at the University of Colorado to show the distance covered by the moving man in a certain period of time (Bozeman Science, 2011). The video by Bozeman Science (2011) further demonstrated steps on how to draw graphs of motion (position versus time graph).
- Video 5: demonstrating a squirrel moving towards and away from the tree as the origin. The video (Caulf, 2011) further demonstrated and describe how best one can draw a graph using the distance covered by the squirrel and time taken to complete the specific distance.

These videos were selected to show learners how to plot a distance versus time and displacement versus time graphs and how to go from that type of graph to a speed versus time or velocity versus time graph. The displacement versus time graph was also used to calculate the velocity of an object, stating and calculating the displacement covered by an object that is in motion. Other calculations related to distance and displacement in graphs of motion were also demonstrated by the two videos (Bozeman Science, 2011; Caulf, 2011). The velocity versus time graph was also used to calculate acceleration (slope of graph) and displacement (area under the graph). Learners were tasked to answer and discuss different questions in their groups and report back.

#### **Overview of lesson 4:**

Interpretations of different graphs of motion.

- Video 6: Interpreting motion graphs (Cash, 2014)

Video showing how to interpret distance versus time, speed versus time and velocity versus time graphs in one dimension was watched (Cash, 2014).

After watching the video, a discussion including teacher explanation and clarification on how to interpret different graphs of motion was done. Learners were assigned pair work interpreting different types of graphs e.g. distance versus time graphs, displacement versus time graphs, speed versus time graphs and velocity versus time graphs.

#### **Overview of lesson 5:**

Constructing graphs of motion and solving graphical problems

The lesson was a revision type of lesson where we synthesised content from previous lessons and learners were administered a range of graphical problems to solve in groups and report back to the whole class, doing individual worksheets on graphs of motion.

#### **Overview of lesson 6:**

Administering post-test

A post-test was administered at the end of the intervention process to all the learners who were part of the intervention. After writing the post-test, learners were asked to write reflections on what they had learned from all the lessons relevant to this study.

#### **Challenges encountered prior to and during the intervention process**

There were some challenges encountered prior to and during the intervention process. All the learners in the grade 11 class wrote the pre-test, however, some learners did not attend the first lesson when the stimulated recall interviews that was done. Upon investigating why they did not turn up, other learners revealed that apparently they were not willing to be interviewed. Some of them only joined in during the third and fourth lesson hence it was difficult to catch up.

### **3.6.4 Learners reflections**

According to Branch and Paranjape (2002), reflections is defined as “a thought, idea, or opinion formed, or a remark made, as a result of meditation. Dewey (1991), states that it is something that is believed in, not on its own account, but through something else which stands as evidence” (p. 8). Learners were given a chance after the intervention to reflect on their graphs of motion learning. According to the National Council for Curriculum and Assessment (NCCA, 2015), giving learners an opportunity to reflect makes them to be more aware of the knowledge and skills they have developed, identify strengths and areas for development as well as where they need to improve, develop and plan for future learning taking into consideration what they did not understand. This will also allow them to gain a greater understanding of themselves and how they learn resulting in the taking more responsibility for their learning (ibid). Excerpts of learner’s reflections are attached on the appendices (Appendix I).

### **3.7 Data preparation**

After data collection, data was prepared by transcription. I transcribed ten audio recordings that were obtained from the stimulated recall interviews. Halcomb and Davidson (2006), highlighted that transcriptions refers to the process of reproducing spoken words, such as those from an audiotaped interview, into written text. According to MaClellan, Macqueen and Neidig (2003), transcription guidelines help researchers to systematically organize and then analyze textual data, regardless of the analytical techniques and tools used. The transcription guidelines help to achieve a high level of certainty that transcripts were generated systematically and consistently (ibid).

Furthermore, Atkinson and Heritage (1984) stressed that the production and use of transcripts are “research activities” and should not be approached as merely a “technical detail” that precedes analysis. MaClellan et al., (2003) describes the transcript as a tool that helps qualitative researchers make sense of and understand interviewees’ experiences and perceptions. They went on to further state that researchers should always remember that what is transcribed, what is not transcribed, and how the transcript is structured influences the analysis process (ibid).

According to Bertram and Christiansen (2015), data reduction is the process of selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes or transcriptions. The process of data reduction happens throughout the whole research process to facilitate the researchers' organising and sorting data into codes or categories and subsequently look for patterns or relationship between these (ibid).

### **3.8 Data analysis**

According to Bertram & Christiansen (2015), and Taylor-Powell and Renner (2003) qualitative data consists of words or text and observations or visual data rather than numbers. They highlighted that data analysis is required to bring order and understanding to the data collected. Similarly, Sargeant (2012), Cohen et al., (2011) and Taylor, Gibbs and Lewins (2010) states that qualitative data analysis (QDA) involves qualitative data that has been collected into some form of explanation, understanding or interpretation of the people and situations or phenomenon being investigated. This is done to make sure that the data collected are making sense when placed in themes, categories and regularities (Cohen et al., 2011 and Taylor, Gibbs & Lewins, 2010).

Qualitative data generated during the research process is analysed inductively and/or deductively to answer research sub- questions. The inductive approach involves organising data into categories and identifying patterns (Bertram & Christiansen, 2015). It involves working from specific observations to a broader generalisations and theories (ibid). On the other hand, in the deductive approach, the researcher can have a clear theoretical frame work or set of concepts and use these to analyse the data (ibid). Although data generated during the research were analysed deductively, showing consideration of the theoretical framework and literature review, inductive analysis were also undertaken to accommodate themes emerged from learners' responses.

Data obtained from learner's prior knowledge on graphs of motion from the learners post-test responses were validated and confirmed with the learners responses from stimulated recall interviews, learners pre and post-test results and reflections were also recorded and this gave room for triangulation. This is shown in the data presentation and discussion chapter on Table 3 and 7 respectively. An analysis of the pre and post-tests results shown in table 5

in chapter four represent a point of data saturation obtained from only four learners and not from all the 21 learners who took part in the intervention.

Analysis of pre-test, stimulated recall interviews and learners reflections was done into stages to provide meaning to the data collected. This involves reading through the data obtained in order to find codes that are answering the research sub-questions and also to compare and contrast them. Similar codes were collated in order to come up with the themes that address the research questions. The themes used results from the codes obtained from the learners' responses in the pre and post-tests, stimulated recall interviews and the learner's reflections on the intervention. Additionally, themes were also identified based on the literature readings on graphs of motion.

Data were explained and discussed later based on the themes that emerged from them. The discussion was strengthened with some referencing from the literature related to the themes as well as from the theoretical frameworks. In the context of this study, data gathered through stimulated recall interviews, pre and post-tests, lessons observations and learners reflections were sorted according to patterns based on the different themes. The themes were categorised according to their similarities and differences and later presented as analytic statements for answering the research questions. I will now discuss the validity of the study.

### **3.9 Validity**

Data validation is defined by Hamilton and Corbertt-Whittier (2013) as the extent to which the findings of the research are accurate or credible. The use of various data from different data gathering techniques, their interpretations and conclusions drawn from them contributes to validity (Thurmond, 2001). In this research, data triangulation is used to improve validity.

Triangulation is defined as the use of two or more methods of data collection (Cohen et al, 2011). Similarly, Creswell and Miller (2000), Polit and Hungler (1999) points out that to obtain accurate representation of reality, data about a phenomenon may be collected in different ways. If triangulation is appropriately used, it might enhance the extensiveness and validation of data in research findings of qualitative research (Thurmond, 2001) and it is therefore a powerful way of demonstrating validity (Cohen et al., 2011). It increases the

amount of time needed in comparison to using single strategies, but provides a better understanding of the problem (Thurmond, 2001).

My critical friend played a major role in validating data at every stage during the research process. Data generated from the pre-test and post-test, stimulated recall interviews, observations, and reflections were shared with the critical friend to clarify any misinterpretations and for improving data validation and reliability. Interview transcripts and video recordings of lessons were then analysed with the assistance of a critical friend, to eliminate researcher bias since I conducted the research with my own learners and I am the one who collected the data. The data from pre-test, post-test, stimulated recall interviews and reflections used during the study was only from learners who attended the intervention i.e. from the first lesson to the sixth lesson.

### **3.10 Ethical considerations**

According to Bertram and Christiansen, (2015) “ethics has to do with behaviour that is considered right or wrong” (p, 65). It is therefore of great importance to consider ethical issues in an action research since it involves humans. Cohen et al (2011) highlighted that before embarking on a research study one should negotiate ownership rights, right to release or withdraw data and right to control access to data. For this reason, I sought permission from the director of education in the region (Appendix A). Appendix B, which is the director of education response through the inspector and the school principal, is also attached. The permission from the circuit inspector, school principal (Appendix C), parents and learners (since they are under age) concerned (Appendix D) in the form of informed consent letters are also attached.

I communicated with the participants about their roles in the process. Participants were also informed that their participation was voluntary and they were allowed to withdraw if they chose not to participate at any point during the research process. In my research report, pseudonyms were used for the learners and the school to keep them anonymous.

According to Bertram and Christiansen (2015), researchers need to be aware of how their own position may influence the respondent views. It is therefore important to establish trust and help learners to be at ease. I invited a critical friend to help me with data validation through avoidance of researcher bias. Since I was working with my own learners in the action

research, I was not a stranger to them. It was a good platform for them to share their experiences with me.

For ethical reasons, all ideas used in this study that are not my own are referenced. To confirm this, they were also checked using Turnitin software in order to avoid plagiarism. This report is attached on the appendices as Appendix J.

### **3.11 Limitations of the study**

The limitations of this study stem from it being a qualitative action research study. However, I attempted minimising the possibility of researcher bias through the inclusion of a critical friend throughout the action research process. The study is limited to 21 grade 11 learners and one Physical Sciences teacher at a school in northern Namibia. Although the results will not be generalized to a larger population, they may provide valuable insight into the possible mediation of graphs of motion through pedagogy of multiliteracies in a real-life situation. Although the use of recording devices might change learners' behaviour, I attempted minimising this by acclimatized them to the recording device in advance of the actual data collection. The strengths of action research including researching my own practice in order to develop myself professionally, provided impetus for the study still going ahead.

### **3.12 Conclusion**

This chapter discussed the study as situated in the interpretive paradigm. It highlight the purpose researching my own practice with the grade 11 learners' on their sense making and disposition towards graphs of motion through the use of a PoM approach. The data gathering methods, research process, sampling, data preparation and analysis, validity, ethical issues and limitation to the study were also discussed. Actual data collected as well as the findings from the analysis are presented and discussed in the next chapter.

## CHAPTER FOUR

### DATA PRESENTATION, ANALYSIS AND DISCUSSION

#### 4.1 Introduction

This chapter presents the data, its analysis and the discussion of the findings of this study. In order to explore the influence of a pedagogy of multiliteracies approach to the grade 11 Physical Sciences learners' sense making of and their dispositions towards graphs of motion, data were gathered using different data gathering techniques. As explained in the methodology chapter, the qualitative data in this study were obtained from the learners pre and post-test, stimulated recall interviews which were based on the learners pre-test, lesson observation of the intervention and learners reflections. Data gathered from each technique was analysed. The themes will now be presented and discussed to answer the research questions. The discussion is guided by the literature and the theoretical frameworks of pedagogy of multiliteracies and social constructivism.

Data in this chapter is presented and discussed in three sections, with each of the sections aligned to answering each of the research sub-questions. I start by presenting and discussing the data to answer research question one on learners' prior knowledge and initial dispositions towards graphs of motion. The discussion is based on analysis of the learner's responses in the pre-test and stimulated recall interviews. Secondly, data from lesson observation of the intervention, post-test and learners' reflections will be presented and discussed. This will be done for triangulation purposes to highlight the link between pre, post-test, observations and what learners have reflected in their reflections in order to check if there is a shift in sense making of graphs of motion. Thirdly, data from observations and reflections will also be analysed and discussed for triangulation purposes to explore any shift in learners dispositions.

Responses of learners during the direct quotes from the learner's pre-test answers, interviews, post-tests answers, and reflections are included where relevant to answering the research questions. This chapter ends with some concluding remarks.

## **4.2 Grade 11 Physical Sciences learners' prior knowledge of and initial dispositions towards science graphs of motion**

Learners were given a pre-test in order to test their prior knowledge of and dispositions towards science graphs of motion. As described in the methodology chapter, ten learners purposively chosen on the basis of different levels of understanding in their prior knowledge evident in the pre-test underwent stimulated recall interviews. All participants' stimulated recall interviews transcripts were collated and analysed together with the pre-test responses.

### **4.2.1 Learners' prior knowledge about graphs of motion**

The pre-test and stimulated recall interviews were used to find learners prior knowledge on graphs of motion from earlier grades and from their own life experiences. From the broad data in the transcripts, I checked for similarities and contrasts. Four themes emerged the results are discussed with the view to answer to the first aspect of research sub-question one on learner's prior knowledge and experiences on graphs of motion.

The following four themes on the learner's prior knowledge on the graphs of motion emerged: kinematics variables, kinematics calculations, graphical understanding and interpretation, as well as drawing of graphs in motion. The table below presents the general picture of the learners' prior content knowledge that is relevant to graphs of motion in order to understand learners' sense making at grade 11 level. This is in line with the suggestion by Lopes et al., (2008) that the teacher should try to identify the students' prior knowledge and check their learning demand to facilitate mediation.

**Table 3: Learners' prior knowledge about graphs of motion**

Prior knowledge theme	Evidence	
	Pre-test	Stimulated recall interviews
Kinematics variables		<ul style="list-style-type: none"> <li>• Acceleration</li> <li>• Deceleration</li> <li>• Change in position</li> <li>• Measuring distance and time</li> <li>• Constant velocity</li> <li>• Zero motion</li> </ul>
Kinematics calculations	<ul style="list-style-type: none"> <li>• Difficulties in calculating velocity (V)</li> <li>• Not able to calculate average speed</li> <li>• Difficulties in calculating acceleration (V)</li> <li>• Difficulties using area under the graphs to calculate distance and displacement</li> <li>• Could write correct formulas for speed, velocity, acceleration, area under the graph but could not use them correctly in calculations (V)</li> </ul>	<ul style="list-style-type: none"> <li>• Can't use the graph to do calculations</li> <li>• Can't use formulas to do calculations</li> </ul>
Graphical interpretations	<ul style="list-style-type: none"> <li>• Could not identify distance and displacement covered</li> <li>• Are not able to interpret velocity and acceleration versus time graphs (V)</li> </ul>	<ul style="list-style-type: none"> <li>• Reading from the graph</li> <li>• Skills needed to explain the graph</li> <li>• Using information from the graph</li> </ul>
Drawing graphs		<ul style="list-style-type: none"> <li>• Find it difficult to draw a graph of how that object change</li> <li>• Showing movement of people or a car on a graph</li> <li>• Showing x-axis and y-axis variables on the graph</li> </ul>

\*\*V - indicates the prior knowledge identified from the post-test and are confirmed through the stimulated recall interviews with the learners

Based on the learners responses from pre-test and stimulated recall interview transcripts, the above themes were identified as part of the prior knowledge held by the grade 11 learners on graphs of motion. The pre-test and stimulated recall interviews were done to explore the relevant prior knowledge on graphs of motion that the learners acquired from the teaching and learning process earlier during the year. The prior knowledge tested was based on graphs of motion interpretations and calculations. A rationalized explanation of the pre-test questions (Appendix E) written by the learners is attached on the Appendices.

#### 4.2.1.1 Kinematics variables

Findings on kinematics variables reveal that learners have a wide range of prior knowledge on kinematic variables. During the interviews most of the learners stated acceleration, deceleration, change in position, measuring distance and time, constant velocity and zero motion as variables that they associate graphs of motion with.

The following are some of the quotes from the stimulated recall interviews (Appendix G) about what the learners' associate graphs of motion with:

##### Excerpt 1

L3- *"graphs of motion is actually graphs that shows the movement of an object for example acceleration, deceleration or explaining when something is moving or stops moving or showing constant motion. I think graphs of motion are not easy because they seem easy but I failed them sometimes. For example I even failed some of the answers in the test we wrote."*

##### Excerpt 2

L5-*"Graphs of motion is maybe a graph that shows how the distance is covered by a moving object"*

##### Excerpt 3

L8-*"Actually I think of graphs of motion as graphs of time, graphs of distance and so on."*

Most of the learners mentioned that graphs of motion are associated with either movement of an object from one point to another or change in position of an object by measuring distance covered and time taken to cover a certain distance. However, they did not mention that *speed* and *displacement* are also variables that are associated with graphs of motion. This

shows that there are some gaps in their prior everyday knowledge on GoM. This is in line with what is stated by Hailikari et al., (2008) that trying to learn something without adequate prior knowledge results in rote memorizations. The gaps in learners' prior knowledge on GoM could be one of the factors contributing to poor performance in the kinematic section of the Physical Sciences syllabus. Speed and displacement are part of the grade 11 curriculum but appear in the grade 10 curriculum as well. This is therefore a challenge to the learners themselves as far as the teaching and learning process in school is concerned because they will not be able to link new knowledge to what they have learned before.

#### **4.2.1.2 Kinematics Calculations**

In terms of kinematics calculations, findings from the stimulated recall interviews (Appendix G), reveal that learner finds it difficult and challenging to work with graphs of motion where calculations are required. Learner one (L1) pointed out that:

Excerpt 4

*“When I am calculating I really have a problem calculating using information from the graphs.” this learner continues by saying, “for example I can do some calculations and not all of them, the difficult one I normally do not do them because I am not good in doing graphs.”*

The DNEA Examiner's report (2008) have shown that learners have a problem of identifying the gradient on the particular graph that represent the acceleration. During stimulated recall interviews, learners expressed their concern about their skills they need to apply on graphs of motion questions that involves a lot of calculations and using different formulas to calculate different kinematic variables taking information from the graph.

During an interview, learner 2 mentioned that:

Excerpt 5

*“The challenge that I have on the skills that I have to apply to the graphs. Sometimes, let me say you are given to draw or plot a graph or something like that. Sometimes if I don’t know which one should be on the x-axis and which one on the y-axis, in most cases I just leave such questions without answering them. And if there is a graph and you are asked to explain what is happening to an object at a certain point, that one is a big problem to me because when I look at the graph I just see lines but then to tell the meaning of those line ayeeee I can’t even if I think about that, I really can’t just get it. And I will just leave it”*

In the same vein, Berg & Phillips (1994), Beichner (1994) and Trumper (1997) stated that learners normally commit “graphs as a picture” error. When learners look at the graph and see it as a picture, they normally do not consider the variable or any other information that is needed to do kinematics calculations. This lead to misunderstanding of the relationships between the variables and incorrect calculations.

#### **4.2.1.3 Graphical Interpretations**

Graphical interpretations are one of the themes in learners’ prior knowledge and it is associated with kinematics graphs. Stimulated recall interviewees (Appendix G) indicated that they are aware of the need for them to interpret graphs but that at times they fail to do it correctly. Learner one (L1) stated that:

Excerpt 6

*“and if there is a graph and you are asked to explain what is happening to an object at a certain point, that one is a big problem to me because when I look at the graph I just see lines but then to tell the meaning of those lines ayeeeeee I can’t even if I think about that, I really just can’t get it.”*

The learners’ pre-test results shows that learners find it difficult to interpret velocity versus time and acceleration versus time graphs correctly and this arose during the stimulated recall interviews as well. They have indicated that they have an idea about how but they do not have the skills on how to fully go about it. In agreement, Beichner (1996) also added that if students do not have a clear understanding of using slope and area, then they cannot interpret the graphs correctly and they cannot make connections between graphs. In the

same way, Friel, Curcio and Brigh (2001), state that to correctly interpret graphs, one can look for relationships among specifiers in a graph or between a specifier and a labelled axis.

#### 4.2.1.4 Drawing of graphs

Drawing of graphs was not part of the pre-test because at the end of the final examinations, learners are mostly only asked to complete the graphs with the variables already included, identify a certain distance or displacement, speed or velocity at a certain point and not necessarily to draw and plot a distance versus time graph, displacement versus time graph, speed versus time graph or a velocity versus time graph. This shows that there is a gap that need to be addressed fully in the NSSCO Physical Sciences curriculum. Zucker et al., (2003) highlighted that understanding graphs is not a mental ability that should be mastered by students but it is a skill that should be learned through training. Just like someone learning how to speak, read or write, students need to construct graphs in order to learn how to use them well (Zucker et al., 2003). After administering the pre-test (Appendix E), I discovered that learner's prior knowledge on drawing graphs of motion is flawed. This came up during the stimulated recall interviews (Appendix G) when they highlighted that they find it difficult to draw graph of how the objects change their motion, and also on identifying where to place the variables on the graph. Learner 2 stated that:

##### Excerpt 7

*"the challenge that I have is on the skills that I have to apply to graphs, the skill is not enough ...Sometimes, let me say you are given to draw or plot a graph or something like that. Sometimes if I don't know which should be on the x-axis and which one on the y-axis, in most cases I just leave such questions without answering them.*

It is clear that learners have gaps in their prior knowledge on the concepts or variables associated with graphs of motion. The lack of prior knowledge identified with pre-test was validated with evidence from stimulated recall interviews. There is therefore a need to consider prior everyday knowledge in order to direct a teachers efforts when helping learners understand of graphs of motion. I now present the grade 11 Physical Sciences learners' initial dispositions towards graphs of motion which emerged from the stimulated recall interview.

#### **4.2.2 Grade 11 Physical sciences learners' initial dispositions towards GoM**

Different initial dispositional indicators emerged from the stimulated recall interviews with the learners before the intervention with the pedagogy of multiliteracies. Seven dispositional themes emerged from the stimulated recall interviews (Appendix G) with the learners. They are summarised in the table below. The themes emerged are: attitudes, confidence, interest, steady effort, responsibility, reciprocity and level of difficulties towards solving graphs of motion questions. Table 4 on the next page shows learners' initial dispositions towards GoM.

**Table 4: Learners' initial dispositions towards GoM**

Dispositional themes		Evidence
Attitudes	Positive attitude	<ul style="list-style-type: none"> <li>• <i>"feel good"</i></li> <li>• <i>"willing to learn"</i></li> <li>• <i>"I enjoy them"</i></li> </ul>
	Negative attitude	<ul style="list-style-type: none"> <li>• <i>"I always loose hope"</i></li> <li>• <i>"I am not good with graph"</i></li> <li>• <i>"I always leave and proceed"</i></li> </ul>
Confidence	High confidence	<ul style="list-style-type: none"> <li>• <i>"I am capable of answering a lot of them"</i></li> </ul>
	Low confidence	<ul style="list-style-type: none"> <li>• <i>"I cannot do them even if I try"</i></li> <li>• <i>"I don't even know how"</i></li> <li>• <i>"I just guess"</i></li> </ul>
Interests		<ul style="list-style-type: none"> <li>• <i>"It is interesting to do and the topic is interesting"</i></li> <li>• <i>"Graphs of motion are actually interesting"</i></li> </ul>
Steady effort		<ul style="list-style-type: none"> <li>• <i>"Practice more"</i></li> </ul>
Responsibility		<ul style="list-style-type: none"> <li>• <i>"Do own research"</i></li> <li>• <i>"Have to practice, read and understand"</i></li> <li>• <i>"Take notes"</i></li> </ul>
Reciprocity		<ul style="list-style-type: none"> <li>• <i>"Learn from each other"</i></li> <li>• <i>"Discussing questions"</i></li> <li>• <i>"Work in groups"</i></li> </ul>
Level of difficulty	Negative level	<ul style="list-style-type: none"> <li>• <i>"I really struggle"</i></li> <li>• <i>"A bit challenging/bit tricky"</i></li> </ul>
	Positive level	<ul style="list-style-type: none"> <li>• <i>"Seems easy"</i></li> <li>• <i>"Are very easy"</i></li> <li>• <i>"Is not something that is difficult to do"</i></li> </ul>

Learners showed both positive and negative attitudes towards graphs of motion. On a positive note, different learners indicated their dispositions as shown in the following excerpts.

Excerpt 8

L3 - *"I always feel good when it comes to graphs of motion because I am a positive person and so I have positive feelings when it comes to graphs of motion".*

Excerpt 9

L2 - *"I am a learner who is willing to learn".*

Besides those learners who showed positive attitudes towards graphs of motion, there were some learners who were negative towards graphs of motion. During the stimulated recall interviews, learner 7 indicated that:

Excerpt 10

*"I don't really see graphs of motion as something good, because they are confusing".* She went on to further state that *"even if I was following I always lose hope when it comes to those graphs".*

Learners have also shown their level of confidence when doing graphs of motion. Of ten interviewees only three learners indicated that they are confident when solving graphical questions. Learners highlighted that:

Excerpt 11

L6 - *"in most cases I can do it without nobody helping me",*

Excerpt 12

L3 - *"I can do graphs of motion very well".*

The majority of learners demonstrated a low level of confidence with graphs of motion. Learner 1 stated that:

Excerpt 13

*"I cannot just ..... when I am look at the numbers, wanted to say, when I look at the car... I .....oh aye....".*

From the above quote one can tell that the learner is not really confident and this might be the cause of her not answering graphs of motion questions well.

Learner one (L1) stated that:

Excerpt 14

*“sometimes I just guess and write my answer and sometimes if I really don’t know the answer I will just leave the question because I don’t have any idea of what to write”.*

During the stimulated recall interviews (Appendix F) with the learners, some have indicated that graphs of motion is an interesting topic although it is challenging when it comes to answering questions. Learner 4 indicated that:

Excerpt 15

*“graphs of motion are actually interesting to do and the topic itself is interesting is just the knowledge that is lacking sometimes when you are answering”.*

Some have indicated that they practice more and keep on trying whenever they encounter some challenging questions regarding graphs of motion – in fact, steady effort was one of the themes that emerged strongly from the interviews. Apart from practising more, learners have also indicated that they have to be responsible for their own learning. Learner 1 suggested that:

Excerpt 16

*“when we are in the lessons we should always discuss things in groups and we can even do home works in groups and present in class because sometimes it help us because if you present something that is correct you will never forget it”.*

Gray (1997) states that the importance of collaboration in social constructivism is that learners can start learning in pair work, group work and team work and later make contributions to the world of knowledge. This allows learners to share thoughts when engaged in different semiotic modes.

Learner 2 stated that:

Excerpt 17

*“maybe we need to search more, do more research and get more worksheets because if we have a lot of worksheets, my performance will improve”.*

Learners have further indicated that being responsible towards their own learning will allow them to perform better in graphs of motion.

Learners have different abilities and so apply different skills and tactics when solving graphical problems. Some have indicated that they are able to solve graphical problems without difficulties and others have indicated that graphs of motions are difficult to solve hence they don't get correct answers most of the time.

During the stimulated recall interviews learner one (L1) stated that:

Excerpt 18

*“Graphs of motion are generally difficult because in most cases I failed to get the answers correct”.*

On the other hand, there are also some learners who have indicated that they find graphs of motion easy to do although they also struggle at times.

### **4.3 Factors enabling/constraining learners sense-making of graphs of motion when mediated using PoM approach.**

#### **4.3.1 Learners' sense-making of graphs of motion**

Learners' were tested before and after the POM approach intervention was carried out. The table below shows the sense-making results obtained from some of the learners who were interviewed before the intervention. The results are based on their pre-test and post-test questions responses depending on the way they did graphical calculations.

Table 5 shows how learners sense-making of GoM has shifted between pre-test and post-test as a result of the PoM intervention.

**Table 5: Learners' shift in sense-making of GoM between pre and post-test results**

Sense-making category	Learner	Pre-test results	Post-test results
Kinematics calculations	L1	<ul style="list-style-type: none"> <li>• Unable to use the graph to calculate area under the graph</li> <li>• Unable to use the graph correctly to find the velocity of an object</li> <li>• Unable to differentiate with calculations the point where the object has greater acceleration and where its acceleration is slower</li> </ul>	<ul style="list-style-type: none"> <li>• Able to calculate area under the velocity time graph</li> <li>• Could read from the graph and able to use the correct formula but could not use the correct values to calculate the velocity of an object</li> <li>• Able to tell where an object has a greater acceleration with clear calculations.</li> </ul>
	L2	<ul style="list-style-type: none"> <li>• Unable to calculate the average velocity</li> <li>• Could write the correct formulas but could not use them in calculations</li> <li>• Unable to read from the graph the distance travelled by an object</li> </ul>	<ul style="list-style-type: none"> <li>• Able to choose the option that indicate the velocity although could not give the explanation</li> <li>• Able to use the formulas correctly in calculations</li> <li>• Could still not use the graph to find the distance covered</li> </ul>
	L3	<ul style="list-style-type: none"> <li>• Unable to calculate the displacement of an object</li> <li>• Unable to calculate the velocity of an object</li> <li>• Unable to use the formula for calculating acceleration correctly</li> </ul>	<ul style="list-style-type: none"> <li>• Still unable to calculate displacement correctly</li> <li>• Could only write the formula for average speed but unable to use it in calculations</li> <li>• Able to use the formula for calculating acceleration and work it out correctly</li> </ul>
	L4	<ul style="list-style-type: none"> <li>• Left the question on calculate velocity</li> <li>• Unable to find the distance travelled by an object from the graph</li> <li>• Could write the formula for acceleration but could not use it correctly in calculations</li> </ul>	<ul style="list-style-type: none"> <li>• Still unable to calculate velocity</li> <li>• Able to read from the graph and find the distance covered</li> <li>• Able to use the formula for acceleration correctly in calculations</li> </ul>
Graphical interpretations	L1	<ul style="list-style-type: none"> <li>• Unable to identify and explain graphs of objects in motion</li> <li>• Could identify graphs but unable to interpret them.</li> </ul>	<ul style="list-style-type: none"> <li>• Able to identify and explain motion of different objects.</li> <li>• Able to identify and interpret the graphs correctly</li> </ul>
	L2	<ul style="list-style-type: none"> <li>• Unable to tell what the meaning of the slope on a position versus time graph</li> <li>• Unable to explain motion of objects moving with constant positive acceleration, zero acceleration, constant positive velocity and constant velocity followed by a decrease in velocity</li> </ul>	<ul style="list-style-type: none"> <li>• Able to explain the meaning of the slope on position versus time graph</li> <li>• Able to explain motions of objects moving with zero acceleration, constant positive velocity, initial constant velocity followed by a decrease in velocity</li> </ul>
	L3	<ul style="list-style-type: none"> <li>• Able to identify with not so clear reasons the diagram with positive constant velocity (<i>because of the same motion</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Could clearly identify with a reason (<i>b, the velocity is constant</i>)</li> </ul>
	L4	<ul style="list-style-type: none"> <li>• Unable to interpret the graph of an object moving with a change in velocity</li> </ul>	<ul style="list-style-type: none"> <li>• Could still not interpret the graph correctly</li> </ul>

On average, the pre-test results shows that most of the learners demonstrated difficulties on how to use the graph to calculate the area under the graph which either shows the distance or the displacement covered by a moving object as they could not make sense of how to do it. Learners were given the chance to do tasks on their own during the intervention process and this allows them to master GoM skills better. After the intervention, the majority of learners were able to calculate the displacement which is shown by the area under the velocity versus time graph. In agreement, Cazden et al. (1996) suggested that students should be allowed to accomplish tasks on their own when they come to conscious awareness of what the teacher has presented and interpreted based on what they have learned. Figures 5 and 6 below shows learner 1's results of calculating the area under the graph before and after the intervention.

(c) What is the displacement covered between 5 and 6 seconds?

$$\begin{aligned} \vec{s} &= \frac{v}{t} \\ &= \frac{15\text{m/s} - 10\text{m/s}}{6\text{s} - 5\text{s}} \\ &= \frac{5\text{m/s}}{1\text{s}} \\ &= 5\text{m/s} \end{aligned}$$

(d) What is the acceleration between 6 and 8 seconds?

Figure 5: Learner 1 pre-test result on calculating area

(c) What is the displacement covered between 5 and 6 seconds?

$$\begin{aligned} \text{disp } \vec{s} &= l \times b + \frac{1}{2}bh \\ &= 10 \times 1 + \frac{1}{2}(1)(5) \\ &= 10 + 2.5 \\ &= 12.5\text{m} \end{aligned}$$

Figure 6: Learner 1 post-test result on calculating area

Most of the learners have shown an improvement in kinematics calculations. This was observed during the lesson as they were able to do the calculations during classwork independently. Learners' reflections have also shown that the intervention process has shaped their skills as they are now able to do kinematics calculations without difficulties.

In their reflections, learner 3 and learner 7 stated that:

Excerpt 19

L3 *"I could not differentiate between distance time graph and velocity time graph, for now everything is going smoothly. I knew now how to calculate acceleration on a velocity time graph and how to read the graph".*

Excerpt 20

L7 *"I learned more things and improved more about graphs. I was not now even to calculate velocity, displacement and acceleration but now I can".*

Even though there are some learners who showed an improvement in kinematics calculations, there were still some learners who could not do graphical calculations for example calculating distance or displacement covered that is shown by the area under the graph correctly although they were able to show the correct formula. This concurs with the conclusion made by Beichner (1994) on his study that, when calculating distance for example, students are able to find distance using the correct formula but they had difficulties in realising that the area under the curve of a speed versus time graphs also represent distance.

Audet et al., (1996) points out that teachers should allow learners to integrate theory with evidence using different semiotic modes to construct meanings. In support of the above, findings before the intervention reveal that many learners were not able to tell what the slope on the position versus time graph represent but this was not the case after the intervention as many were then able to explain that the slope on the position versus time graphs shows the velocity. Findings reveals that the intervention process promotes students understanding when the teacher allowed learners to integrate theory and evidence as they were able to do graphical explanations after the intervention correctly.

The diagram below shows learner 2 responses on the meaning of the slope on the position versus time graphs before and after the intervention. The pre-test and post-test results show that the learner's skills improved.

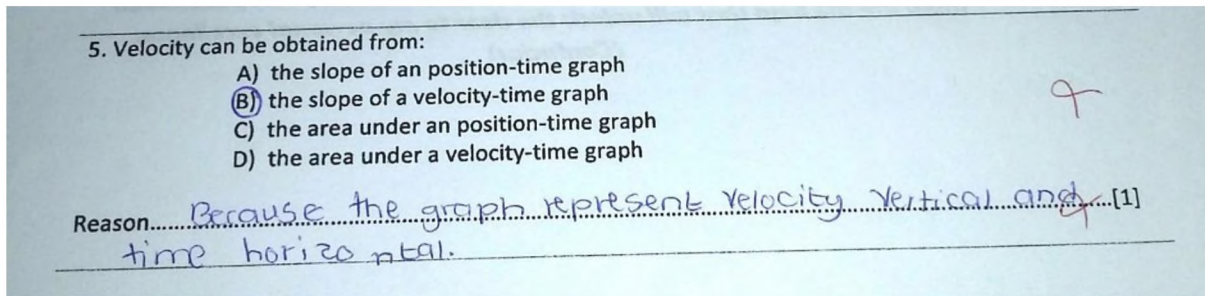


Figure 7: Learner 2 pre-test result on the meaning of the slope

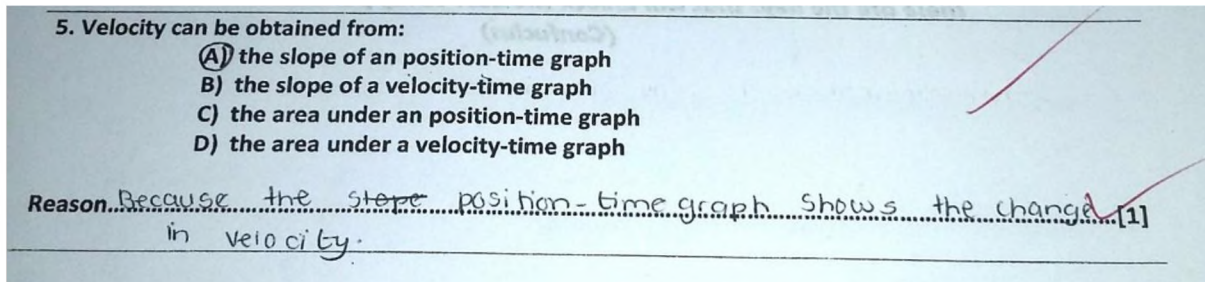


Figure 8: Learner 2 post-test results on the meaning of the slope

Although there are learners whose results showed that they were able to make sense of graphs of motion by interpreting the graphs correctly, this was still not the case with learner 4 because both pre-test and post-test results bear the same fruits as he was still not able to interpret the graph of an object that was moving with a change in velocity correctly.

Figure 9 and Figure 10 below shows learner 4 graph interpretation results before and after the intervention.

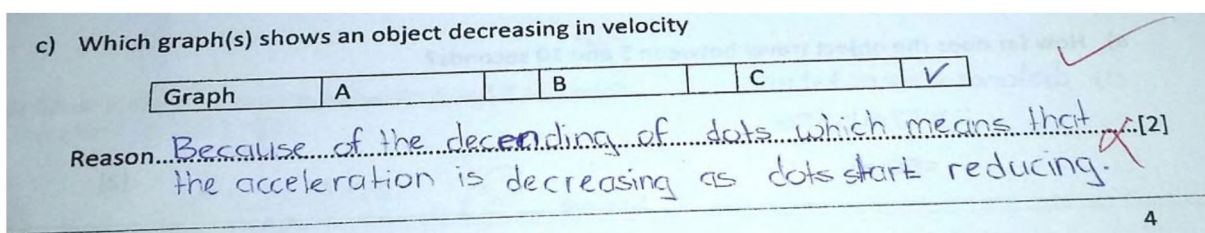


Figure 9: Learner 4 pre-test result on graph interpretation

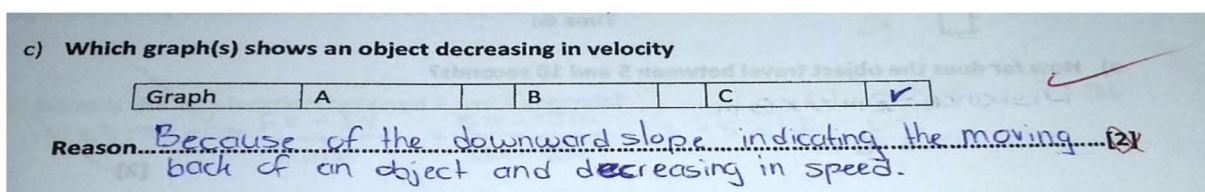


Figure 10: Learner 4 post-test result on graph interpretation

There is no shift in understanding detected in this learner over the course of the intervention as shown by the pre-test and post-test responses above.

I now present the factors that enable and constrain learners sense-making when mediated through a PoM approach.

### 4.3.2 Enabling and constraining factors

During the intervention, some factors that enable and constrains learner’s sense- making of graphs of motion when mediated through the PoM approach were observed. These factors are explained below.

**Table 6: Factors enabling and constraining learners sense making of GoM**

Enabling factors		Constraining factor	
The use of semiotic modes of representation	<ul style="list-style-type: none"> <li>• Doing explanations using power point representation with pictures and texts</li> <li>• Linking physical representations to solve problems</li> </ul>	Lack of conceptual knowledge	<ul style="list-style-type: none"> <li>• Unable to differentiate slope and area on the graph</li> <li>• Lack graphical interpretation skills</li> </ul>
Inclusion of prior everyday knowledge	<ul style="list-style-type: none"> <li>• Doing explanation linking them to everyday experiences</li> <li>• Giving examples from their everyday experiences</li> </ul>		
Getting help from more knowledgeable others	<ul style="list-style-type: none"> <li>• Discussing with one another</li> <li>• Working out their answers in groups</li> <li>• Teacher learner and learner teacher interaction</li> </ul>		

#### 4.3.2.1 The use of semiotic modes of representations

The use of semiotic modes of representations is one of the factors contributes strongly to learners sense-making of GoM. This was achieved through the use of power point presentations during the course of the interventions which shows text and pictures, videos as well as drawings. In their reflections (Appendix I), learners have indicated that the use of

videos was effective. The following are some of the quotes from the learners' reflections on the effectiveness of using videos during the lessons:

Excerpt 21

L1 *"When I was watching those videos this was really useful because I have learned things that I never knew before and this helped me to improve my knowledge on this topic, now I understand it fully"*

Excerpt 22

L11 *"I found the strategy of video watching useful more especially because the teacher stop the video in order for her to explain more and give us chance to ask questions"*

Excerpt 23

L16 *"the video clips we have watched gave me a clear understanding of how those graphs one can get information from them"*

The use of different semiotic modes of representations proves to be an enabling factor as learners were clearly able to see and explain what is happening to an object that is in motion. Kitson et al., (2007) agree and stresses that the focus on multiliteracies through semiotic systems affords learners opportunities to develop shared understanding of visual texts and how they work. The findings are also in agreement with Ainsworth (2008) who claimed that if learners can see a moving motorcycle at the same time as the velocity versus time graph, then it might help them understand that a horizontal line means uniform motion rather than no motion at all. The use of different semiotic modes more especially the videos allow learners to link physical representations in order to solve problems and interpret graphs of motion.

Additionally, Abersêk (2008) agrees that the use of visual literacies in teaching and learning enable students to acquire the ability to understand, how new and visual media produce meanings. Through this learners were able to use their multiple abilities and skills to interpret visual texts that represent an object that is in motion.

#### 4.3.2.2 Inclusion of prior everyday knowledge

The second enabling factor is on the use of prior knowledge to help learners make sense of graphs of motion. According to Cazden et al., (1996), active interventions on the part of the teacher should focus on the learners' experiences and activities and allow them to gain explicit information when it can most usefully guide the practice and build on what they already know.

The following are some of the quotes from the learners' interviews (Appendix G) on the effectiveness of the inclusion of prior everyday knowledge during the lessons:

Excerpt 24

*"Instead of teaching maybe we can do something better, for example after introducing graphs of motion we can even use a car or person running and stopping and see how best we can show those movement of people or a car on a graph".*

Excerpt 25

*"we can relate to real object, for example if it is a graph of motion may be of a car moving, then we should look at the car, measure the distance, time and work it out on the graph. And things like explaining the graph will be easy because it was based on something that we have seen ourselves".*

Mukwambo (2012) agrees that if learners' prior everyday knowledge and experiences are considered during science lessons then learners will develop interest in science as it allow them to link their cognitive and affective aspects to science learning. As observed during lessons, learners were able to explain motion of different types of objects and link them to their everyday experiences by giving relevant examples. There is a need to assess learner's prior learning and experiences before commencing with science teaching and learning in the classroom for the new information to always build on what the learners already know and experienced.

#### 4.3.2.3 Getting help from more knowledgeable others

Thirdly, getting help from more knowledgeable others is also one of the factors that enable learners to make sense of graphs of motion. Learners were able to discuss with one another and share ideas regarding how to solve graphical problems. They were able to work out their answers in groups and help one another as to how to overcome different types of graphical problems. The teacher worked collaboratively with learners to construct meaning and this is shown in Figure 11 below. This is in line with what Cazden et al., (1996) points out - that it is done through the use of people who have mastered certain experiences and these are the people who are responsible for guiding learners previous and current experiences as this forms an integral part of their learning.



**Figure 11: learners working in groups with the assistance of the teacher**

During the intervention, the teacher mediated learning by playing the role of a more knowledgeable other in order to help learners make sense of graphs of motion leading to a more meaningful practice. This is in line with what Vygotsky (1978) suggested - that the more knowledgeable other help learners by scaffolding them intellectually and this will help them to carry out tasks when they are alone. The teacher-learner interactions strengthen the bond between the teacher and learners helping them to learn from each other. Learners' interaction with classmates allow them to practice and understand the value of classroom activities within a community of learners with the help of a teacher (Cazden et al., 1996). Learners were allowed to interact with one another in their groups until they reach a consensus.

#### **4.3.2.4 Lack of conceptual knowledge**

Findings from learners pre-test reveals that learners seems to lack the conceptual knowledge that is linked to graphs of motion. This is the only constraining factor that hindered learners' sense making of graphs of motion. Learners were not able to differentiate the slope and the area on the graph and as a result they also lack graphical interpretation skills. Similarly, Lavertya and Kortemeyerb (2012) equally mentioned that when learners lack understanding of the subject matter behind them, they fail to understand the connections between graphs and the real world and have difficulties in reading and interpreting graphs. Beichner (1994) found out that students usually do not know when to use the slope or area of interpretation of a given graph and in most cases they read values off the axes and directly assign them to the slope of a given graph.

The following section present the influence of the PoM on learners' dispositions towards graphs of motion.

#### **4.4 PoM approach influence on learners' dispositions towards GoM**

Learners showed different dispositional indicators before the intervention (but just after they received their pre-test results). The following are the dispositional themes that emerged from the lessons observations (Appendix H) and from the learners' reflections (Appendix I) after the post-test. These are: - positive attitudes, high confidence, interest, steady effort, reciprocity and playfulness.

The table below shows a shift in learners' dispositions towards learning GoM before and after employing the PoM approach during the lessons.

**Table 7: Shift in learners dispositions from pre to post-test**

<b>Disposition al theme</b>	<b>Learne rs</b>	<b>Initial dispositions</b>	<b>Final dispositions</b>
Positive attitudes	L5		<i>"I feel so good"</i>
	L6		<i>"I am proud"</i>
	L7		<i>"Graphs of motion is now my best topic, I am feeling proud"</i>
	L8	<i>"I always feel good" "I have positive feelings"</i>	
	L9	<i>"I am willing to learn"</i>	<i>"I feel proud"</i>
High confidence	L5	<i>"Am well with graphs of motion" "I can do it"</i>	
	L6		
	L7	<i>"I go through them to see if I can answer them"</i>	<i>"If I happen to compare these lessons with flowers, those flowers were colourful" "If the question comes, it will be like a piece of cake to me"</i>
	L8	<i>"I can do them well"</i>	<i>"My confidence is greater than the previous time"</i>
	L9	<i>"Am capable of answering a lot of them"</i>	<i>"I am 99% if not 100% that I will answer the questions perfectly"</i>
Interest	L5		
	L6	<i>"They are actually interesting"</i>	
	L7		
	L8	<i>"Graphs of motion is very interesting"</i>	<i>"They were interesting"</i>
	L9		<i>"I found it helpful and interesting"</i>
Steady effort	L5	<i>"I always try more"</i>	
	L6	<i>"By practising more" "I always deal with them"</i>	<i>"It was blood sweat and tears"</i>
	L7	<i>"Go through these questions"</i>	
	L8		
	L9	<i>"Practice more"</i>	
Reciprocity	L5	<i>"Form groups in and be taught in groups"</i>	
	L6	<i>"Do group work or pair work" "We can teach one another" "You can correct and guide us"</i>	
	L7		
	L8	<i>"Doing things in group" "Help us learn from each other" "I try and approach somebody else"</i>	
	L9		<i>"Bringing our answers together and defend them" "Discussing the answers with the whole class" "Interesting working in groups"</i>
Playfulness	L5		<i>"They were so enjoyable"</i>
	L6		<i>"It later got to the point of excitement" "It was a great moment" "They were fascinating, useful and enjoyable"</i>
	L7		<i>"They were enjoyable"</i>
	L8		<i>"They were very fun"</i>
	L9		<i>"They were enjoyable"</i>

Learners only showed positive attitude as compared to the negative attitudes that was showed by most of the learners before the intervention. After the intervention with the pedagogy of multiliteracies approach most of the learners attitudes changed from negative to positive. The following excerpts shows some positive dispositional indicators from the learners' reflections.

Excerpt 26

*"I feel so good because we have to improve because we now understand very well"*

*"I felt good to attend the lessons"*

*"I am proud I gain some knowledge and I know more about graphs of motion unlike before"*

This is in line with Anku (1996) who highlighted dispositions as a change in learners' attitudes as a result of an intervention in a non-threatening classroom environment that is helping students develop concepts through a variety of activities that are related to real life experiences. Indeed learners showed a change in attitudes as a result of the PoM intervention towards graphs of motion.

The learners also showed an improvement on their level of confidence towards graphs of motion. Initially, learners depicted low levels of confidence towards graphs of motion. After the intervention all the learners showed that they were confident when solving graphical motion questions. Learner seven (L7) stated that:

Excerpt 27

*"I am feeling proud to receive such knowledge and if I could get questions on graphs of motion then it will be like a piece of cake to me".*

Another learner (L8) compared his level of confidence to how it was initially. He stated that:

Excerpt 28

*"I can do them well", to how it is after the intervention "my confidence towards graphs of motion is now greater than the previous time"*

Findings from the learners' reflections shows that they find the topic on graphs of motion interesting. Findings also reveals reciprocity as a dispositional theme that brings about the shift in their dispositions. Learner (L9) indicated that:

Excerpt 29

*"it was helpful and interesting getting to work in groups more especially when everyone answers questions on their own and then bring our different answers together then everyone will be defending his/her own answers for others to consider it correct then we will discuss the answers with the whole class together with the teacher"*

In agreement, Bull and Anstey (2006) point out that PoM can change learners' interactions by encouraging them to take more responsibility of their learning, shifting the locus of control from the teacher to them and spurring them to engage in more substantive conversations. Additionally, Gresalfi (2009) agree and asserts that student's individual participation, small group work and the teacher intervention shape productive dispositions and learners opportunities to learn.

Playfulness emerged from the learners' reflections as one of the dispositional themes after the PoM approach. Most of the learners indicated that it was enjoyable being part of the lessons because they have learned a lot compared to what they knew before the intervention. Crick and Goldspink (2014) supports the above by stating that individuals should be allowed to reflect on their approach to learning for them to begin navigating their own pathway through the curriculum rather than depending on the teacher's direction.

Learners reflections allow them to gain necessary theoretical skills from what they have learned, critique it constructively (Cazden et al., 1996) and eventually innovate on their own by encouraging them to think, understand, observe, interpret and apply their ideas when learning and solving graphical problems. I now present the concluding remarks for this chapter.

#### **4.5 Conclusion**

In this chapter I presented and discussed the data gathered through multiple techniques: pre-test and post-test, stimulated recall interviews, lesson observations and learners reflections. Although there were still a few learners who demonstrated challenges when

answering questions after the PoM intervention, the findings reveal that overall, learners' sense making benefited from the PoM intervention.

Furthermore, the findings reveal that the majority of learners initially had a negative attitude towards graphs of motion, but that this changed after the intervention with all the learners then showing a positive attitudes towards learning graphs of motion. In the next chapter the conclusions drawn from this study, some recommendations and limitations are presented.

## CHAPTER FIVE

### SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

#### 5.1 Introduction

This chapter summarises the main findings from my study and discuss the extent to which the findings answer the research questions. The purpose of this study was to explore the influence of Pedagogy of multiliteracies approach on the grade 11 Physical Sciences learners' sense making of and dispositions towards graphs of motion.

Recommendations are made in relation to how Physical Sciences teachers can provide opportunities for grade 11 Physical Sciences learners to solve graphical problems and its related concepts. Recommendations will also be made concerning the use of learners' prior knowledge from earlier grades and the use of different modes of representations for addressing the challenges Grade 11 Physical Sciences learners face when solving problems related to graphs of motion.

The limitations of my study will be discussed before I present critical reflections of my research journey which will be followed by the conclusion of the chapter.

#### 5.2 Summary of findings

The data collected was analysed in order to answer the three sub research questions.

##### 5.2.1 Research question 1: What are the grade 11 Physical Sciences learners' prior knowledge of and initial dispositions towards GoM?

###### 5.2.1.1 Learners' prior knowledge on GoM

In response to the first part of research question one, the results presented in Chapter 4 (Section 4.2.1) revealed the grade 11 Physical Sciences learners nature of prior knowledge on graphs of motion. Findings revealed that learners have prior knowledge on different themes that emerged from their pre-test and stimulated recall interviews. This includes their prior knowledge on different kinematics variables, kinematics calculations, graphical interpretations as well as drawing of graphs.

Learners have indicated that they are aware of different kinematics variables, for example

- *Acceleration*
- *Deceleration*
- *Velocity*
- *Distance*
- *Time*
- *Change in position*

However learners could not mention that *speed* and *displacement* are also variables that are associated with kinematics graphs. Hence the results presented shows that the grade 11 Physical sciences learners lack some prior knowledge on kinematics variables. There is therefore a need for Physical sciences teachers to consider learner's prior knowledge in their teaching to improve learners understanding of graphs in motion.

The second finding related to learners' prior knowledge involved kinematics calculations. Learners had difficulties working with graphs of motion when there are calculations involved. The pre-test results had indicated that they find it difficult to calculate average speed, velocity, acceleration as well as using the area under the graph to calculate either distance or displacement. This results in them simply leaving out questions that involve calculations.

Another finding on learners' prior knowledge relates to graphical interpretations. Findings revealed that the majority of learners lacked graphical skills needed to explain the different parts of the graphs. Lastly, results also revealed drawing of kinematics graphs as another challenge arising from gaps in prior knowledge. Findings showed learners' finding it difficult to correctly allocate different variables on the graph axes. This results in them finding it difficult to draw graphs of objects in motion.

#### **5.2.1.2 Learners initial dispositions towards graphs of motion**

In response to the second part of research question one, on learners' initial dispositions (Chapter 4, Section 4.2.2), findings reveal different dispositional indicators towards learning graphs of motion. Learners showed both positive and negative attitudes towards graphs of motion, most of them lack confidence when they are presented with challenging tasks on

graphs of motion because they have indicated that they don't even know how to do it even if they try to do it. Findings further revealed that graphs of motion is an interesting and not a difficult topic to do. Learners only need to practice more, do more research, share their ideas and work together in groups in order to gain the necessary skills needed to solve graphical problems.

## **5.2.2 Research question 2: What factors enable/constrain learners' sense-making of graphs of motion when mediated using pedagogy of multiliteracies approach?**

### **5.2.2.1 Shift in learners' sense making of GoM**

In response to the first part of the second research question, findings indicated that there were shifts in learners' sense making of GoM (Chapter 4, Section 4.3.1). Findings on learners' pre-test and post-test reveal that some learners' sense making on graphs of motion has changed as a result of the intervention with the PoM approach. The learners' pre-test results shows that the majority of learners had difficulties on how to interpret and use the graphs to perform calculations but after the intervention only a few of them were not able to do it correctly.

### **5.2.2.2 Factors enabling and constraining learners sense making of GoM**

The data presented in chapter 4, Section 4.3.2 revealed that learners' sense-making of graphs of motion is influenced by the following enabling factors - the use of semiotic modes of representations, the inclusion of prior everyday knowledge, the use of more knowledgeable others; and constraining factor - lack of conceptual knowledge. Findings reveal that most learners prefer the use of multiple representations such as video watching, with pictures and drawings useful in helping them solve graphical problems and interpreting the graphs of motion. The use of learners' prior knowledge and experiences by linking what they are learning to what they already know also proved helpful in making them link what they are familiar with to the learning of graphs of motion. Findings also reveal that the interaction during discussion with the teacher and other learners helped them learn. Lastly, findings reveal that learners' lack of conceptual knowledge and understanding of graphs in general resulted in difficulties making sense of graphs of motion.

### **5.2.3 Research question 3: How does the pedagogy of multiliteracies approach to teaching influence learners' dispositions towards learning graphs of motion?**

#### **5.2.3.1 Shift in learners dispositions as a result of using PoM approach**

In response to the third research question Chapter 4, Section 4. 4, the findings indicated that there are strong shifts in learners' dispositions towards graphs of motion. Learners' negative attitudes, low confidence, interest, steady effort, reciprocity and playfulness shifted drastically after the intervention with PoM approach. Findings reveal that the use of different semiotic modes of representation such as videos, pictures, diagrams, signs and symbols brought about a positive shift in learners dispositions towards graphs of motion.

Learners have indicated that they wish all the sections could be retaught using the same approach as in this research, as it has helped them master the skills and knowledge needed to solve graphs of motion problems. Learners have highlighted that the lessons were interesting and enjoyable compared to the normal teaching and learning process during school hours. They have enjoyed watching the videos and engaging in group discussion because they feel that it improved their understanding of graphs of motion.

### **5.3 Recommendations**

The findings of my study reveal that consideration of learners' prior everyday knowledge and the use of pedagogy of multiliteracies approach during teaching and learning helps learners to make sense of graphs of motion and brings about a positive change in their dispositions towards graphs of motion.

In light of my findings, I recommend the following:

- Teacher education training programs should emphasise the importance of identifying and working from learners' prior everyday knowledge. Teachers need skills on how to incorporate it in the process of teaching and learning.
- Teachers could enrich their science classes with the PoM to engage learners meaningfully in the classroom. This may positively change learners' attitudes towards learning GoM and science in general.

- Teachers should encourage group work as this will not only enhance learning but also allow for learners to be more active in the learning process.

#### **5.4 Limitations of the study**

The research was limited to ten grade 11 learners and one Physical Science teacher at a school in northern Namibia. Because of this the results are not generalizable to the larger population because of differences in contexts. However it has provided useful insights for me as a science teacher, into how learners make sense of graphs of motion and how their dispositions changed when it was mediated through a pedagogy of multiliteracies approach.

The fact that I wore the hats of both teacher and researcher at the same time was both a strength and a limitation. It could be a limitation because some learners could have made statements during the interviews or when writing their reflections just to please me since I am their Physical Sciences teacher. It was a strength in the sense that it helped in establishing a strong relationship with learners and make them feel at ease during the lessons as well as during the stimulated recall interviews because they are used to me during formal school lessons. The support of a critical friend helped minimise any possible researcher bias.

The use of recording devices might change learners' behavior and the findings might reflect a partial view of what is really happening. To minimise this, learners were acclimatize to the recording device in advance of the data collection.

#### **5.5 Reflections**

My research journey has been both challenging, and rewarding. From the time I started working on my research proposal to the point of completing the thesis, I have grown as a science teacher and researcher. I acknowledge the support from my supervisor, colleagues and my research participants.

I encounter the challenge of a critical friend withdrawing at the last minute when I was about to start with data collection. I then decided to approach my colleague who is mathematics teacher but has Physical Sciences experience, to be my critical friend. Compiling the thesis was another challenge in my research journey as I had to pull all the threads together in order to make sense to the readers.

I believe that my research journey has helped me look at things critically. The one on one supervision with my supervisor during the contact sessions, attendance at a colloquium and research design course were all helpful during my research journey. I have learned many things during my research journey. Reading literature provided me with many ideas that I needed to understand and engage with before proceeding with writing. My writing style is improving on an ongoing basis. I have learned how to first draft for myself and then re-draft for the readers to understand my writing.

Since my study employed action research methodology, I am planning to teach the next cycle (second cycle) by designing further PoM activities relating to graphs of motion. I am also planning to redesign the test used during this cycle in order to better identify the range of learners' misconceptions/challenges. Learners will be allowed to keep journals where they are going to record their progress/challenges at the end of each lesson taught.

## **5.6 Conclusions**

In this study I explored the influence of the PoM approach on the grade 11 Physical Sciences learners' sense making of and dispositions towards graphs of motion. The sense making was based on the inclusion of the learners' prior knowledge, using different semiotic modes of representations and making use of a more knowledgeable person during group discussions. Learners in this research study lacked conceptual understanding of graphs of motion variables which can allow them to interpret graphs and solve graphical problems correctly. The study also reveal that the use of PoM intervention in a classroom setting allows learners to participate willingly and reflecting on their learning and brings about shift in their dispositions towards graphs of motion.

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## APPENDICES

### APPENDIX A: LETTER TO THE REGIONAL EDUCATION DIRECTOR



**RHODES UNIVERSITY**

Grahamstown • 6140 • South Africa

Laina N. Mwiiyale  
P. O. Box 326  
Oshakati  
Cell: 0812856469  
E-mail: [lynamwii@gmail.com](mailto:lynamwii@gmail.com)

EDUCATION DEPARTMENT  
Tel: +27 (0) 46 603 8383  
Fax: +27 (0) 46 622 8028  
PO Box 94, Grahamstown, 6140  
E-mail: [education@ru.ac.za](mailto:education@ru.ac.za)

To: The Director of Education  
Ministry of Education, Arts and Culture  
Omusati Regional Council  
Private Bag 523  
Outapi

Dear Sir

**RE: REQUEST FOR PERMISSION TO CARRY OUT A MASTER OF EDUCATION RESEARCH IN SCIENCE EDUCATION AT [REDACTED] SECONDARY SCHOOL**

In alignment with the Rhodes University Ethical Standards, a consideration of ethics is fundamental to all research. Therefore, as a researcher, I have a responsibility to ensure that the research is ethical. The research is ethical in the sense that it displays ethical principles such as respect and dignity, transparency and honesty, accountability and responsibility, and integrity and academic professionalism.

I, LAINA NATANGWE MWIIYALE, Employee code M2703198400232, student number, 13M6792, a teacher at Onawa Secondary School in Anamulenge circuit and currently registered for the SECOND and final year of the 2015-2016 MEd Science programme in Education. As part of this course, one of my responsibilities is to carry out a research requiring questionnaires, intervention and observations related to the research (half-thesis). The purpose of the research is to explore the influence of multiliteracies approach on grade 11 Physical Science learners' conceptions and dispositions towards graphs of motion.



Therefore, I hereby request your support in granting me access and permission to [REDACTED] Secondary School so that I can conduct the educational research using interviews, intervention and observations with relevant learners.

As noted above, this is an educational research so it will be circulated or published beyond the Education Department at Rhodes University with regard to participants consents. Should you have any further queries or concerns, please do not hesitate to contact me personally or Mr Kavish Jawahar (My MEd in Science Education ,Supervisor) at the following email address: [k.jawahar@ru.ac.za](mailto:k.jawahar@ru.ac.za).

Yours Sincerely

**LAINA NATANGWE MWIIYALE (13M6792)**  
MEd in Science Education Student  
Rhodes University

**APPENDIX B: LETTER FROM THE REGIONAL EDUCATION DIRECTOR**

REPUBLIC OF NAMIBIA

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**OMUSATI REGIONAL COUNCIL**

**DIRECTORATE OF EDUCATION, ARTS AND CULTURE**  
*Team Work and Dedication for Quality Education*

Tel: +264 65 251700  
Fax: +264 65 251722

Private Bag 529  
OUTAPI  
19 April 2016

Enq: Apollonia Hango

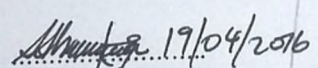
Laina Natangwe Mwiiyale  
Onawa Secondary School  
Anamulenge Circuit

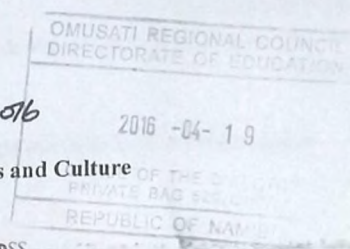
**Subject: Permission to carry out a Master of Education Research in Science Education.**

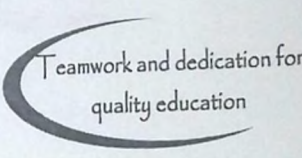
This letter serves to notify you (Ms. Laina Mwiiyale) that permission has been granted to conduct a research at ██████████ Secondary School on the influence of multiliteracies approach on grade 11 Physical Science learners' conceptions and dispositions towards graphs of motion. Please be informed that the research to be conducted at school should by no means whatsoever disrupt teaching and learning.

We hope and trust this exercise will enhance quality education in the Region.

Yours faithfully

 19/04/2016  
Mr. Laban Shapange  
Director of Education Arts and Culture





Cc: The Principal for ██████████  
Inspector of Education for Anamulenge Circuit

*All official correspondence must be addressed to the Chief Regional Officer.*

## APPENDIX C: LETTER TO THE PRINCIPAL

17 July 2016

Dear Sir

My name is Laina N. Mwiiyale and I am a M.Ed. student registered at Rhodes University in Grahamstown South Africa. My cell phone numbers are 081 285 6469 / 081 690 5000.

As my research project, I have chosen to conduct research on Physical Science learner's dispositions and sense making of graphs of motion and would like to conduct the research at your school. The project title is: Exploring the influence of multiliteracies approach on the grade 11 Physical Science learners' sense making and dispositions towards graphs of motion. The emphasis of my study is mainly on the connections made by the Grade 11 Physical Science learners and different semiotic modes used when learning graphs of motions during Physical Science lessons. These might help them solve graphs of motion without any difficulties. Your school's context complements the requirements for my study since it is a secondary school and the grade 11 NSSC learners learning graphs of motion is part of their NSSC Physical Science learning objectives.

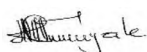
If you choose that the school should not participate, it will not be prejudiced against in any way. If you decide that the school will participate, I will conduct a pre-test of with the group of Grade 11 Physical Science learners identified as a suitable sample. An interview will also be conducted with the Physical Science learners (focus group) chosen on the basis of their responses to the pre-test questions. I will then need to video record about 4 lessons in the Grade 11 classroom to be taught by me, as the Physical Sciences educator and researcher. Learners will be interviewed after the lessons. Interviews will be done after school hours as per agreement with the director of Education in Omusati region to avoid disruption of classroom activities during school hours. Learners will also be administered a post test. The data collection will be done if there is consent from you, the concerned Grade 11 Physical Science learners and their parents. The recording will be stored by me for a period of 5 years after use, and then be destroyed. Your name, the name of your school as well as the name of the Grade 11 Physical Science learners, will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or for the Grade 11 Physical Science learners involved, and you may withdraw from the study at any stage and for any reason, without prejudice.

My research project is being supervised by Mr. Kavish Jawahar from Rhodes University, Education Department in Grahamstown. For further information and clarification regarding the research project he can be contacted at the following telephone number: +27 76 983 2538, or alternatively via his email address: k.jawahar@ru.ac.za.

If you agree for your school to participate in my research, please complete the attached consent form and if possible, call me on the number mentioned above, so I may collect the form. I thank you for taking the time to read this letter.

(Please complete the declaration on the next page, and let me know when I may collect it).

Yours sincerely



Laina N. Mwiiyale (13m6792)

MEd Science student

INFORMED CONSENT DECLARATION FORM FOR PRINCIPAL

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I ..... (full name of principal), the principal of .....  
(full name of school) hereby confirm that I understand the contents of this document and the nature  
of the MEd research project by Laina N. Mwiyale, and I provide informed consent for my school  
participating in the research project.

I understand that my school is at liberty to withdraw from the project at any time.

**Name of Principal**

**Signature of Principal**

**Date**

.....

.....

.....

## APPENDIX D: LETTER TO THE PARENT AND CONSENT FORM

17 July 2016

Dear Parent

My name is Laina N. Mwiyale and I am a M.Ed. student registered at Rhodes University in Grahamstown South Africa. My cell phone numbers are 081 285 6469 / 081 690 5000.

As my research project, I have chosen to conduct research on Physical Science learner's dispositions and sense making of graphs of motion and would like to conduct the research at your child's school. The project title is: Exploring the influence of multiliteracies approach on the grade 11 Physical Science learners' sense making and dispositions towards graphs of motion. The emphasis of my study is mainly on the connections made by the Grade 11 Physical Science learners and different semiotic modes used when learning graphs of motions during Physical Science lessons. These might help them solve graphs of motion without any difficulties. Their school's context complements the requirements for my study since it is a secondary school and the grade 11 NSSC learners learning graphs of motion is part of their NSSC Physical Science learning objectives.

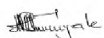
If you choose your child not participate, it will not be prejudiced against in any way. If you decide that the child will participate, I will conduct a pre-test of with the group of Grade 11 Physical Science learners identified as a suitable sample. An interview will also be conducted with the Physical Science learners (focus group) chosen on the basis of their responses to the pre-test questions. I will then need to video record about 4 lessons in the Grade 11 classroom to be taught by me, as the Physical Sciences educator and researcher. Learners will be interviewed after the lessons. Interviews will be done after school hours as per agreement with the director of Education in Omusati region to avoid disruption of classroom activities during school hours. Learners will also be administered a post test. The data collection will be done if there is consent from you, the concerned Grade 11 Physical Science learners and their school principal. The recording will be stored by me for a period of 5 years after use, and then be destroyed. Your name, the name of your school as well as the name of the Grade 11 Physical Science learners, will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or for the Grade 11 Physical Science learners involved, and you may withdraw from the study at any stage and for any reason, without prejudice.

My research project is being supervised by Mr. Kavish Jawahar from Rhodes University, Education Department in Grahamstown. For further information and clarification regarding the research project he can be contacted at the following telephone number: +27 76 983 2538, or alternatively via his email address: k.jawahar@ru.ac.za.

If you agree for your child to participate in my research, please complete the attached consent form and if possible, give it to your child and I will collect it from him/her. I thank you for taking the time to read this letter.

(Please complete the declaration on the next page, and let me know when I may collect it).

Yours sincerely



Laina N. Mwiyale (13m6792)

MEd Science student

INFORMED CONSENT DECLARATION FORM FOR PARENTS/GUARDIANS

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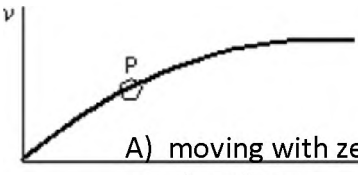
I ..... (full name of a parent/guardian), a parent/guardian of ..... (full name of a child) schooling at ..... (full name of a school) hereby confirm that I understand the contents of this document and the nature of the MEd research project by Laina N. Mwiiyale, and I provide consent for my child to participating in the research project.

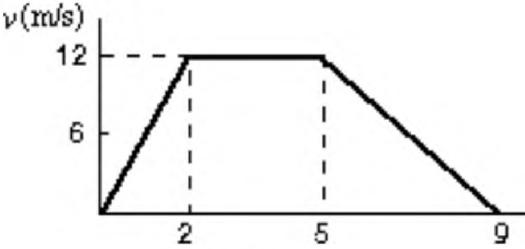
I understand that my child is at liberty to withdraw from the project at any time.

<b>Parent's name</b>	<b>Parent's signature</b>	
Date.....	.....	.....

<b>Learner's name</b>	<b>Learner's signature</b>	<b>Date</b>
.....	.....	.....

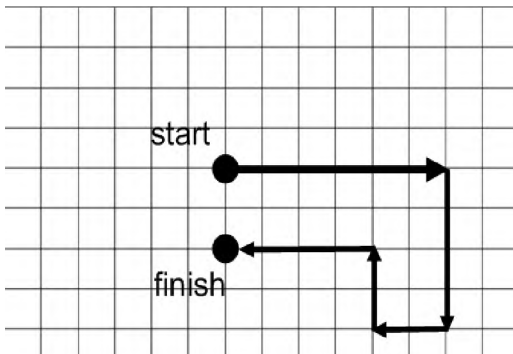
**APPENDIX E: PRE-TEST AND POST-TEST QUESTION PAPER WITH MARKING GUIDELINES**

Questions	Expected answers	Reasons for selecting/asking those questions
<p><b>SECTION A</b></p> <p>1. A car starts from Outapi, goes 50 km in a straight line to Oshikuku, immediately turns around, and returns to Outapi. The time for this round trip is 2 hours. The magnitude of the average velocity of the car for this round trip is:</p> <p>A) 0                      B) 50 km/hr                      C) 100 km/hr D) 200 km/hr</p> <p>Reason..... ..... [1]</p>	<p align="center">A</p> <p>Reason (s) :</p> <ul style="list-style-type: none"> <li>• One revolution is completed from Outapi to Oshikuku and back again.</li> <li>• The difference between the final position and the initial position of the object is zero.</li> <li>• The net displacement is zero</li> </ul>	<ul style="list-style-type: none"> <li>• Calculating velocity proves problematic to the learners. This is highlighted in the national Examiner’s report (DNEA, 2009)</li> </ul>
<p>2. The area under a <u>velocity-time graph</u> represents:</p> <p>A) acceleration B) change in acceleration C) change in velocity D) displacement</p> <p>Reason.....[1]</p>	<p align="center">D</p> <ul style="list-style-type: none"> <li>• The area under the velocity time graph is the displacement covered</li> </ul>	<ul style="list-style-type: none"> <li>• Learners lack prior knowledge on graphs of motion (Hailikari, Katajavuori and Lindblom-Ylänne (2008). This question aims to test learners prior knowledge on graphs of motion.</li> <li>• Interpret the graphs in order to identify when the body is moving with changing velocity. This is one of the learning objectives highlighted in the Namibian curriculum (Namibia, Ministry of Education, 2009). This question also tests whether learners confuse a graph with the actual path that the object is moving in.</li> </ul>
<p>1. The diagram shows a velocity-time graph for a car moving in a straight line. At point P the car must be:</p>  <p>A) <u>moving with zero acceleration</u> B) climbing the hill C) accelerating D) stationary</p> <p>Reason.....[1]</p>	<p align="center">C</p> <ul style="list-style-type: none"> <li>• Velocity increases with time</li> </ul>	

<p>4. A particle moves on the x axis. When its velocity is positive and increasing:</p> <p>A) its acceleration must be positive  B) its acceleration must be negative  C) its acceleration must be zero  D) it must be slowing down</p> <p>Reason.....[1]</p>	<p>A</p> <ul style="list-style-type: none"> <li>Acceleration is the rate of change of velocity</li> </ul>	<ul style="list-style-type: none"> <li>Identify linear motion for which acceleration is constant or not. This is in line with the learning objective as highlighted in the Namibian curriculum (Namibia, Ministry of Education, 2009).</li> </ul>
<p>5. Velocity can be obtained from:</p> <p>A) the slope of a position-time graph  B) the slope of a velocity-time graph  C) the area under a position-time graph  D) the area under a velocity-time graph</p> <p>Reason.....[1]</p>	<p>A</p> <ul style="list-style-type: none"> <li>Velocity is equal to the slope of the displacement time graph</li> <li>The slope of the graph of displacement as function of time is equal to the velocity at that time</li> </ul>	<ul style="list-style-type: none"> <li>Testing their understanding of knowledge based graphs and see whether they are able to make sense or not since they lack an understanding in graphical representation of motion (DNEA, 2008, 2009, 2010, 2013 and 2014).</li> </ul>
<p>6. The graph represents the straight line motion of a car. How far does the car travel between <math>t = 2</math> seconds and <math>t = 5</math> seconds?</p>  <p>A) 4 m  B) 12 m  C) 24 m  D) 36 m</p> <p>Reason.....[1]</p>	<p>D</p> <ul style="list-style-type: none"> <li>Distance is equal to the area under the graph.  <math>= l \times b</math>  <math>= 12 \times 3</math>  <math>= 36 \text{ m}</math></li> </ul>	<ul style="list-style-type: none"> <li>Learners are expected to use the area under the graph to determine the distance / displacement travelled by the object in motion (Namibia, 2009).</li> <li>This is also highlighted in the Examiner's report (DNEA, 2010 and 2012) that learners find it difficult to determine the distance or the displacement covered by a moving object which is represented by the area under the graph.</li> </ul>

SECTION B

1. Use the graphic below of a person walking to answer the questions which follow. Assume that each square is equal to one meter and that it took 18 seconds to walk from start to finish.



a) What distance did the person walk from start to finish? [1]  
Reason.....  
.....  
.....[1]

b) What is the displacement of the person from start to finish? [1]  
Reason.....  
.....  
.....[1]

c) What was the average speed of the person walking from start to finish? [2]

d) What was the average velocity of the person walking from start to finish? [2]

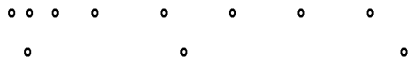
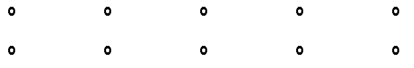
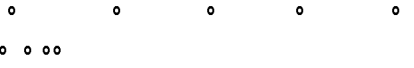
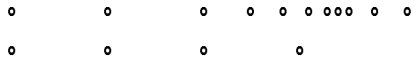
a) 18 squares x 1m = 18m  
Reason: the person covers 18 squares from the start to the end.

b) 2m south  
**Reason:**  
• 2 squares from the starting point to the finishing point.  
• Straight distance (displacement) from the start to the finishing point covers 2 squares.

c) Average speed = total distance/total time  
= 18m/18s  
=1m/s

d) Average velocity = displacement/time  
= 2m/18s  
=0.1 m/s South

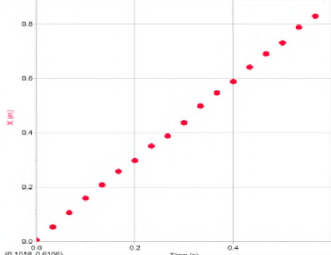
- Test learners understanding towards a graphs that represent motion since they lack an understanding of graphical representations of motion (DNEA, 2008, 2009, 2010, 2013 and 2014).
- Learners also lack prior knowledge on graphs of motion and this is highlighted by Hailikari, Katajavuori and Lindblom-Ylänne, 2008).
- Learners find it difficult to determine the distance covered by a moving object and this is a major problem as it is highlighted in almost all the examiner’s report (DNEA, 2008, 2009, 2010, 2013 and 2014).
- Have difficulties in reading and fail to understand the connection between graphs and real world (Lavertya and Kortemeyerb, 2012).
- Identify when the body is at rest, moving with constant or changing speed. This is one of the Namibian learning objectives expectations (Namibia, 2009).
- Identify linear motion of which acceleration is constant or not (Namibia, 2009).
- Learners lack the skills needed when solving graphical problems and graphics representation of motion( DNEA, 2008, 2009, 2010, 2013 and

<p>2. Each of the four motion diagrams below shows the distance of an object at successive 1-s time intervals Use the following diagrams to answer questions (i) – (iv).</p> <p style="text-align: center;"><b>BEGIN</b>                      <b>END</b></p> <p><b>A</b></p>  <p><b>B</b></p>  <p><b>C</b></p>  <p><b>D</b></p>  <p>(i) Which diagram shows an object with constant positive acceleration? Reason..... .....[2]</p> <p>(ii) Which diagram shows an object with zero acceleration the entire time? Reason..... ..... [2]</p> <p>(iii) Which diagram shows an object with constant positive velocity Reason.....[2]</p>	<p>i) A or D <b>Reason:</b></p> <ul style="list-style-type: none"> <li>• <i>A moves with an increase in velocity</i></li> <li>• <i>D moves with a decrease in velocity</i></li> </ul> <p>ii) B <b>Reason:</b> <i>velocity is constant throughout</i></p> <p>iii) B <b>Reason:</b> <i>the distance covered by the object after every 1 second interval is the same</i></p>	<p>2014 and Hailikari et al, 2008).</p> <ul style="list-style-type: none"> <li>• Have difficulties in reading and fail to understand the connection between graphics and real worlds (Lavertya and Kortemeyerb, 2012).</li> <li>• Interpret the graph to identify when a body is moving with constant, changing speed, velocity or acceleration</li> </ul> <p>This is one of the Namibian physical science syllabus expectations (Namibia, 2009).</p> <ul style="list-style-type: none"> <li>• Test learners understanding of graphs of motion, solving graphical problems because learners have demonstrated difficulties in reading and interpreting graphs (DNEA, 2008, 2009, 2010, 2013 and 2014).</li> </ul>
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(iv) Which diagram shows an object with initial constant velocity followed by a decrease in velocity?  
Reason.....[2]

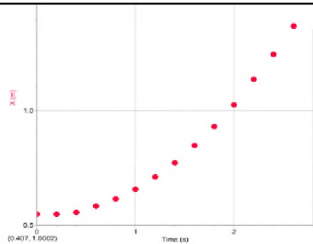
3. Use the following distance (x-m) vs. time (s) graphs to answer the questions that follow. Give reasons to support your choice.

Distance vs Time



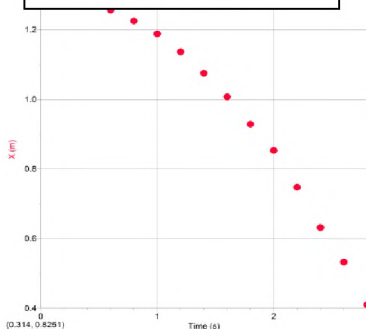
A

Distance vs time



B

Distance vs Time



C

a) Which graph(s) show a constant speed?

Graph	A
-------	---

Reason.....  
.....  
.....[2]

iv) C  
**Reason:** *it moves with a decrease in velocity until it slows down*

a) Graph A  
**Reason:**

- *displacement and time increases with equal amounts*
- *the dot graph shows that each consecutive dot is the same distance apart...*
- *slope/gradient is constant*

- Calculating velocity proves problematic to the learners, and learners also find it difficult to determine the distance covered by a moving object.

- These are some of the requirements / learning objectives as highlighted in the curriculum (Namibia, 2009). Apart from that, they also proved problematic to the learners as highlighted in the examiners reports (DNEA, 2010 and 2012).

- The syllabus expect learners to calculate acceleration for motion with constant velocity (Namibia, 2009).
- Learners are also expected to use the area under a particular graph to determine the distance travelled by the object in motion but this proved

b) In which graph(s) is the acceleration zero?

Graph	A	B	C	
-------	---	---	---	--

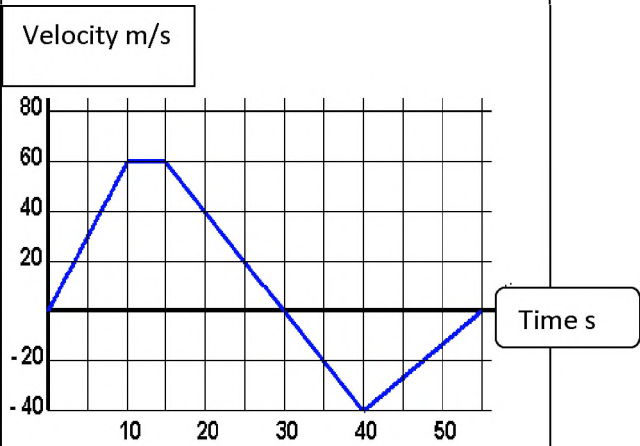
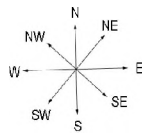
Reason.....[2]

c) Which graph(s) shows an object decreasing in velocity

Graph	A	B	C	
-------	---	---	---	--

Reason.....  
 .....  
 .....[2]

4. Refer to the following velocity vs. time graph for the following questions.



a) What is the acceleration of the object from 15 seconds to 40 seconds? [3]

a)  $a = \frac{\text{change in velocity}}{\text{change in time}}$   
 $= \frac{-40 - 60}{40 - 15}$   
 $= \frac{100}{25}$   
 $= 4 \text{ m/s}^2 \text{ south east}$

b) What is the displacement of the object between 10 and 15 seconds? [2]

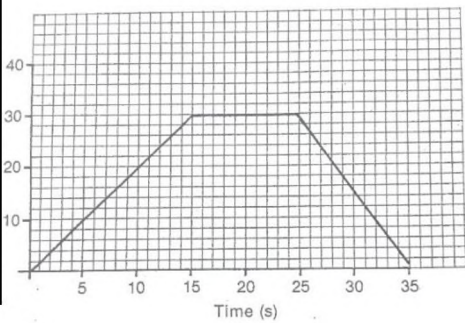
b)  $s = l \times b$  (area under the graph)  
 $= 60 \times 5$   
 $= 300 \text{ m}$

c) What is the displacement of the object between 30 and 40 seconds? [2]

c)  $a = \frac{1}{2}bh$   
 $= \frac{1}{2} (40 \times 10)$   
 $= \frac{1}{2} (400)$   
 $= 200 \text{ m}$

problematic as the majority of them finds it difficult to determine the distance covered by a moving object, represented by the area under the speed or velocity time graph (Namibia, 2009 & DNEA, 2010 and 2012).

5. Study the graph below and solve graphical problems highlighted



a) How far does the object travel between 5 and 10 seconds? [2]

a)  $20\text{ m} - 10\text{ m} = 10\text{ m}$

b) How far does the object travel between 15 and 20 seconds? [2]

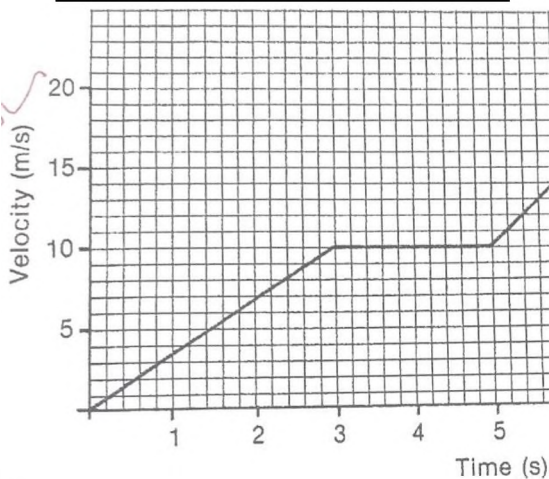
b)  $30\text{ m} - 30\text{ m} = 0\text{ m}$

c) What is the velocity between 15 and 20 seconds? [2]

c)  $v = \frac{v_f - v_i}{t}$   
 $= \frac{20 - 20}{20 - 15}$   
 $= \frac{0}{5}$   
 $= 0\text{ m/s}$

6. Study the velocity vs time graph below and answer the questions which follow.

Velocity vs time



c

<p>a) Is the acceleration greater between 2 and 3 seconds or between 5 and 6 seconds? Show how you arrived at your answer</p> <p>(i) Show with calculations how you arrived at your answer [3]</p> <p>(ii) Explain how you could give your answer without doing calculations [2]</p>	<p>a)(i) <i>Between 2 and 3 seconds</i>  <math>a = \text{change in velocity} / \text{change in time}</math>  <math>= 10 - 6 / 3 - 2</math>  <math>= 4 / 1</math>  <math>= 4 \text{ m/s}^2</math></p> <p><i>Between 5 and 6 seconds</i>  <math>a = 15 - 10 / 6 - 5</math>  <math>= 5 / 1</math>  <math>= 5 \text{ m/s}^2</math></p> <p><i>Acceleration is greater between 5 and 6 seconds</i></p> <ul style="list-style-type: none"> <li>(ii) The slope is greater between 5 and 6 seconds as compared to the slope between 2 and 3, and slope of v vs t graph gives the acceleration.</li> </ul> <p>By comparing steepness of slopes.</p>	
<p>(b) During what time interval is the acceleration zero? [1]</p>	<p>b) <math>a = \text{change in velocity} / \text{change in time}</math>  <math>= 10 - 10 / 5 - 3</math>  <math>= 0 / 2</math>  <math>0 \text{ m/s}^2</math></p> <p>Or slope is zero between 3 and 5 seconds</p>	
<p>(c) What is the displacement covered between 5 and 6 seconds? [1]</p>	<p>c) <math>s = \frac{1}{2} (a+b)h</math>  <math>= \frac{1}{2} (10+15)1</math>  <math>= 12.5 \text{ m}</math></p> <p>Or  <math>S = lb + \frac{1}{2}bh</math>  <math>= 10 \times 1 + \frac{1}{2} \times 5 \times 1</math>  <math>= 10 + 2.5</math>  <math>= 12.5 \text{ m}</math></p>	
<p>(d) What is the acceleration between 6 and 8 seconds? [1]</p>	<p>d) <math>a = v/t</math>  <math>= 5 - 15 / 8 - 6</math>  <math>= -10 / 2</math>  <math>= -5 \text{ m/s}^2</math></p>	

## APPENDIX F: SAMPLE OF STIMULATED RECALL INTERVIEW QUESTIONS GUIDELINES

These questions will stimulate their memory and help the researcher to get more details on their initial attitudes and sense making towards graphs of motion (research sub-question 1) based on their test results.

Some of the questions are guided by learner's scripts responses and there are follow-up questions depending on their responses to the questions.

QUESTIONS	REASONS FOR SELECTING/ASKING THOSE QUESTIONS
1. What do you think about graphs of motion?	Give their opinions about graphs of motion. This could both be the strength or weaknesses and back them up with evidence for example the ones in the test script when they are answering/solving GoM questions.
2. What are your views regarding graphs of motion lessons?	This question will allow me to know how the learners view / observe previous graphs of motion lessons.
3. Do you see yourself as someone who can do graphs of motion without difficulties? If yes, give reason. If no, why not?	Want to find out if they are able to solve graphical problem questions correctly with no help, little help or not at all and also whether they are able to interpret graphs of motion. This question is guided by their responses in the test scripts
4. What do you think of your performance? Which possible teaching/learning methods should be most effective in order to change your performance?	What they think about their performance and what makes them perform the way they have performed. I also want them to suggest factors/strategies that can be implemented during GoM lessons to help them perform better.
5. What measures do you apply when you don't know the answer?	I want to find out what they really do in case if they do not know the answer this is because similar questions were left unattended and were also wrongly answered in some learner's scripts who attempted them.
6. What challenges do you encounter when learning graphs of motion?	Find out their understanding of GoM concepts, and what makes them fail to make connections between graphical questions and real world which brings about difficulties in reading and interpreting graphs and these in turn causes poor performance.
7. What is your biggest challenge when answering graph of motion questions? What solutions do you suggest for to overcome those challenges?	Want to find out the major challenges faced by learners when answering/solving graphs of motion problems and also suggested ways that can be used to address those challenges.
8. What do you think will make graphs of motion lessons interesting and enjoyable?	I would like to find the strategies they think will enable them to learn GoM better and also some other strategies that will make the lessons interesting. Want them to enjoy the lessons by providing me with something that I should consider when planning the interventions as this might help the lessons to be more successful.

## APPENDIX G: TRANSCRIPTS OF COLLATED INTERVIEWS AND CODING

### Stimulated recall interviews codes

Sense making	Dispositions
SM-C calculations	D-PA positive attitude
SM-U understanding	
SM-CP change in position	D-CN confidence
SM-LK lack of knowledge	D-P playfulness
SM-I interpretation	D-I interest
SM-PK prior knowledge	D-SE steady effort
SM-SE seeking explanation	D-NA negative attitude
SM-UN unanswered	D-R reciprocity
SM-IA identifying axis	D-PR perseverance
SM-S strategies	D-CU courage

#### 1. What do you think about graphs of motion?

*Give their opinions about graphs of motion. This could both be the strength or weaknesses and back them up with evidence for example the ones in the test script when they are answering/solving GoM questions.*

**SRI1L1:** Graphs of motion is like when you use a graph and take even a number from that graph to calculate (SM-C) how the object is moving.

**Follow up question:** Can you explain further?

**Follow up SRI1L1:** I think graphs of motion are generally difficult (SM-U) because in most cases I failed to get the answers correct. For example when I am given a graph of velocity and time, and you take one number from velocity and one number from time and then just to calculate using those number is not easy (SM-U).

**SRI1L2:** Graphs of motion mmmmmh hhhh.....

**Follow u question:** In other words, could you give me your opinions based on graphs of motion?

**Follow up SRI1L2:** To me graphs of motion I think it just, it is not easy, it is not difficult, (SM-U) it is just there

**SRI1L3:** Graphs of motion is actually graphs that shows the movement of an object for example acceleration, deceleration, or explaining when something is moving or stops moving, or showing constant motion. I think graphs of motion are not easy because they seems easy but I failed them sometimes (SM-U). For example I even failed some of the answers in the test we wrote.

**SRI1L4:** Graphs of motion I think of them as graphs that describes the change in position (SM-CP) by measuring distance and time.

**Follow up question:** graphs of motion that describes change in position, may you clarify that?

**Follow up SRI1L4:** Like when an object is changing from one point to another, then one can draw a graph of how that object change the position

**SRI1L5:** Graphs of motion is maybe a graph that shows how the distance is covered by a moving object (SM-CP).

**SRI1L6:** I think graphs of motion are the graphs that describe the movement of an object (SM-CP) and this graphs are not really easy so to say (SM-U). I think it is just those graphs.

**SRI1L7:** Graph of motion are those graphs that are very confusing (SM-U) and difficult to understand (SM-U) because they can be used to show the distance covered by an object and time taken (SM-CP)

**SRI1L8:** Actually, I think of graphs of motion as graphs of time, graphs of distance and so on.

**Follow up question:** Can you explain that further?

**Follow up SRI1L8:** We use graphs of motion... we describe them using time, distance and the change in position(SM-CP) when you use graphs

**SRI1L9:** These are the graphs that shows or describe the movement of object(SM-CP) how far the object moves in relation to time

**SRI1L10:** These are graphs that shows the motion of an object (SM-CP), whether it is fast, slow or whether the object is not moving

## **2. What are your views regarding graphs of motion lessons?**

*This question will allow me know the learners better, in terms of how they view / observe previous graphs of motion lessons.*

**SRI2L1:** When I am calculating I really have a problem calculating (SM-C) using information from the graphs.

**SRI2L2:** Graphs of motion is not something that is difficult to do, it is not easy it only requires an understanding (SM-U), for example if you know what you are doing and you really understand it very well then you can do it without any problem. But then this becomes a problem sometimes because we have lack of knowledge (SM-LK) since we don't have enough material like text books.

**SRI2L3:** I actually view them as something that is simple although in actually fact they are not simple. I always feel good (D-PA) because am a positive person so I have positive feelings when it comes to graphs of motion, I can do them well (D-CN) and I have to do those ones as I enjoy (D-P) them very much although it is not always the case.

**SRI2L4:** I regard graphs of motion as something that is challenging to me. When I am learning graphs they always seems to be easy but when am writing I really don't know what is happening (C), as I don't always get them as I am expecting. Sometimes when I look at graphs I view them as good things coz am learning more and knowing more and ok ah am and experiencing more about graphs. Graphs of motion are actually interesting (D-I) to do and the topic is interesting is just the knowledge that is lacking (SM-LK) sometimes when you are answering for example.

**Follow up question:** interesting? Tell me more.

**Follow up SRI2L4:** Yes Ms. Graphs of motion is very interesting especially when you see an object moving and then again you have to represent the movement of that object with just lines, drawing

lines. It is interesting (D-I) but at the same time it is also a bit challenging if you are lacking the skills to draw that graph. It is not just easy to draw a graph (SM-U).

**SRI2L5:** I don't think it's really good but I just try (D-SE) and I am also not doing well in graphs (SM-LK).

**SRI2L6:** I can say, graphs of motion themselves are interesting (D-I) but at the same time they are a bit tricky. One need to be well informed about graphs to do them well (SM-U).

**SRI2L7:** I really don't see them as something good because they are very confusing (C). Even the lesson is just confusing. Even if I was following I always loose hope when it comes to those graphs (D-CN). I really do not understand them very well (SM-U) especially when it comes to answer questions regarding graphs of motion. Sometimes it is hard for me to answer the questions. It is not easy to answer questions on graphs of motion

**SRI2L8:** I think graphs of motion, I can be asked to state the motion the object is moving. For example an object can be moving on constant velocity or zero motion. The lesson sometimes are interesting (D-I) but then I only end up confused (C) because I don't understand them (SM-U).

**SRI2L9:** Graphs of motion seems to be easy (SM-U), even when you are in class during the lesson they are easy but when the questions come you don't know how to answer them (C) or sometimes you know but you will just loose hope (D-CN) of what you are doing, you will say that it's not correct but anyway it will not be correct but it's the easy way only that we don t take it easy and sometimes we don't understand (SM-U) what we are doing.

**SRI2L10:** Graphs of motions are very easily, I can say I am well with them

**3. Do you see yourself as someone who can do graphs of motion without difficulties? If yes, give reason. If no, why not?**

*Want to find out if they are able to solve graphical problem questions correctly with no help, little help or not at all and also whether they are able to interpret graphs of motion. This question is guided by their responses in the test scripts*

**SRI3L1:** Yes Ms,

**Follow up question 1:** but how can you do that if earlier on you have indicated that you have problems in calculating?

**Follow up SRI3L1:** For example I can do some calculations (SM-C) and not all of them, the difficult one I normally do not do them because I am not good in doing graphs (D-NA).

**Follow up question 2:** I have looked at your scripts, but most of them problems are not solved correctly. Could you tell me reasons why you only opt to do some questions?

**Follow up SRI3L1:** I have tried (D-SE) that, even in my summary when am studying I use to do that, but when am coming to my paper I will be confused (C).

**Follow up question 3:** Ok, let's look at this question here, it is a graph of motion question representing the movement of the car, how far a car travels between two and five seconds. So, now it's a question that requires you to calculate the distance that is covered but looking at this, you did not get it correct. And also looking at the other one it is still the same thing.

May be, so, what is the problem, what are the challenges that you are facing whenever it comes to that?

**Follow up SRI3L1:** I cannot just..... when I am look at the number, wanted to say when I look at the car... I .....oh ayeee.

**SRI3L2:** Yes, actually I am a learner who is willing to learn (D-R) because sometimes these questions on graphs of motion are not really tough, am capable of answering a lot of them but not all. But the problem only comes when there is a graph that I need to explain (SM-I), to be honest I wouldn't even know where to start explaining

**SRI3L3:** Yes Ms.

**Follow up question:** Why are you saying that?

**Follow up SRI3L3:** Graphs of motion is very interesting (D-I). This is because I understand more (SM-U) about the movement of objects, for example the accelerating and the decelerating or even constant motion of objects. And from my general knowledge in terms of being in a car (SM-PK), that shows me by giving me an examples of how the graphs are in general physics.

**SRI3L4:** Only some questions that I get them right and some I don't, only few of them that I get right.

**SRI3L5:** I am not good in graphs (D-NA), it is not easy for me to answer some questions

**SRI3L6:** Yes, sometimes I can do graphs of motion very well (D-CN) without anybody's help. But there are times when I cannot just do them even if I try (D-SE) to do them. It is not an easy thing to do.

**SRI3L7:** Yes, sometimes I have to try (D-SE) by myself. But to be honest graphs of motion are very confusing (C), I can't do them on my own (D-NA).

**SRI3L8:** Definitely, am not that good (D-NA) with graphs but then I try my best just to try (D-SE) and answer them

**SRI3L9:** Yes I can try to do it (D-SE), because some of the questions are not really difficult only that I used to get confused (C) between those different types of graphs.

**SRI3L10:** Yes Ms, because in most cases I can do it (D-CN) without nobody helping me

4. **What do you think of your performance? Which possible teaching/learning methods should be most effective in order to change your performance?**

*What they think about their performance and what makes them per form the way they have performed. I also want them to suggest factors/strategies that can be implemented during GoM lessons to help them perform better.*

**SRI4L1:** My performance is not good at all

**Follow up question 1:** What are you suggesting that we should do so that you can do better next time?

**Follow up SRI4L1:** And when we are in the lessons we should always discuss things in groups (D-R) and we can even do home works in groups and present in class because sometimes it helps us because

if you present something that is correct you will never forget it. I should always ask questions (SM-SE) and take notes (NT) when the teacher is teaching so I can use them later.

**Follow up question 2:** Ok, do you have some other things that are in place, for example ok, so.. We are going to talk about, maybe I am suggesting that we should do this and that and that... this might help me. So, do u have something like this, maybe a strategy so that your performance can be better?

**Follow up SRI4L1:** Yes Ms, when we are in class, like when we are going to do in class, when we are doing something you should ask me, you should point me to go and do something on the chalkboard

**SRI4L2:** I cannot really say I am happy with my performance, sometimes I am but this are the only times because at times those questions come and I wouldn't even know where to start when am answering them (SM-U). Instead of teaching maybe we can do something better, for example after introducing graphs of motion we can even use a car or person running and stopping (SM-PK) and see how best we can show those movement of people or a car on a graph. Which I think it is not an easy thing to do. The other thing that we need to do is that. Maybe we need to need to search more, do more research, and get more worksheets (R) because if we have a lot of worksheet my performance will improve. For example if I did not do well in that worksheet then I need to research more and practice more (D-PR) till I get them correct. And when similar question comes, I will be able to answer it. The other thing that we should do is that we should also be given textbooks (R) and sometimes we also need to do our own research in the computer lab because we do not have text books. And I think the worksheets (R) that we have are not enough and they are the only one we rely on.

**SRI4L3:** At this point am actually not pleased with the way I have performed. Actually I have to go through my summary book and read more about graphs of motion, use my understanding (SM-PK) on graphs of motion and general knowledge so that it can help me improve. The other thing that I think will help us get better marks on graphs of motion is maybe group work. I always find it very helpful when we are doing things in group (D-R) because this always helps us to learn from each other. Like sometimes we have questions but then you don't want to ask in class because some learners always laugh at one another, so I think group work will really help in this case.

**SRI4L4:** I do not really perform well in this topic, so I can say my performance is better as compared to some people in our class. Jaaa, by practising more (D-SE) on them and also may be we can always do group work or pair work (D-R) during the lesson. Or sometimes you can give us a chance, like in the afternoon when we don't have lessons and then we can teach one another (D-R) whilst you are also there so that you can correct and guide us (TR).

**SRI4L5:** My performance I think is not good. I think it is very poor. I don't even know how to describe my performance. But yes, it is very poor. May be for the teacher when they are teaching to relate to real things (SM-PK).

**Follow up question:** Ok, could you give me an example of real things you are referring to?

**Follow up SRI4L5:** Like the things that I know, instead of just talking about things that we are not sure of. For example it can be a car coming from a certain direction while we are observing.

**SRI4L6:** My performance is kind of, like, let me say kind of better. Sometimes I study in those Physical Sciences modules whereby I got some help from the grade 12 especially those ones that are doing

higher level. Aah, I think you need just to allow us to practice more (D-SE), pose questions (SM-SE) where I don't understand and test myself when I don't understand.

**Follow up question:** what are some of the ways or teaching strategies that you are suggesting should be done so that you can turn around your performance?

**Follow up SRI4L6:** Ah I think , we can also teach by relating to real object (SM-PK), for example if it is a graph of motion may be of a car moving, then we should look at the car, measure the distance, time and work it out on the graph. And things like explaining the graph will be easy because it was based on something that we have seen ourselves.

**SRI4L7:** Am not happy with this performance at all, I did not do well just because I did not perform and this is because I don't understand (SM-U) and I failed to answer the questions.

**Follow up question 1:** what are you suggesting that should be done in order to improve your performance? Look at your script her, you scored 6/50.

**Follow up SRI4L7:** I am suggesting, ,like to go through this questions and to go through other books about graphs (D-SE), I will go through them to see if I can answer them and if I could not then maybe I can help from you (TR).

**Follow up question 2:** in terms of teaching methodology, like how should the lesson be presented to you?

**Follow up SRI4L7:** Ok, maybe we should be introduced to the lesson by first looking at real things that are happening around us (SM-PK). We can even go to the road and look at the cars that are passing and we come back and explain how to draw the graphs.

**SRI4L8:** No, I am not happy coz the marks that I have scored are very low and my performance is very poor. I am not good with graphs (D-NA), I really struggle a lot (SM-U) with graphs of motion. Before teaching, I need to do research more on graphs of motion and try to find out some information from textbooks, ;like Physical science books and any other source (R) that have graphs of motion information. And maybe we can use group work (D-R) during the lesson, they are very helpful.

**SRI4L9:** My performance is not that bad, all I can say is that it is moderate.

**Follow up question:** ok, now I want that performance to shift from where it is now to above average. So, how can you change that performance? What strategies do we need to include to change that?

**Follow up SRI4L9:** May be we can have a lesson whereby we are only discussing questions and we give the answers or we can work in groups (D-R) and report back. But apart from that I want to practice more (D-SE), search about motion, ask my classmate where I don't understand for me to improve.

**SRI4L10:** I think I am not good in graphs at all (D-NA), I wish I could do much more. We need to form groups in class and be taught in those groups unlike when we are a lot and the class is very full. And I also have to practice, I will also read and understand (D-CU).

## 5. What measures do you apply when you don't know the answer?

*I want to find out what they really do in case if they do not know the answer this is because similar questions were left unattended and were also wrongly answered in some learner's scripts who attempted them.*

**SR15L1:** Like measuring graphs?

**Follow up question:** No, what I meant is, if you are given a test paper for example, and there are some questions that you don't understand. What do you do in such cases?

**Follow up SR15L1:** Sometimes I just guess and write my answer and sometimes if I really don't know the answer I will just leave the question because I don't have any idea of what to write. I will always try (D-SE) and come to school so that you can help me. When we do this, I will try to ask questions from you and then you can.....

**SR15L2:** Sometimes I try (D-SE), for example thinking of other things and connect them (SM-PK) to what is in the question paper, like sometimes I have to think about a car moving on the road, may be speeding and all those things but if I cannot get the answer then I always leave and proceed to the next question

**SR15L3:** First of all I look at the question and see if I can understand it (SM-U), if I cannot, if I don't understand it then I always try (D-SE) and guess because that's the only option that I have.

**SR15L4:** There are some that I leave blank (SM-UN) and some I try (D-SE) them even if I am not sure whether the answers are correct or not. See, sometimes I have to think, but if I kept on doing that and I am not getting the answer that I the only position that I am left with Ms. because sometimes if I write nonsense then it will not look good.

**Follow up question:** ok, why do you leave some blank?

**Follow up SR15L4:** Actually, I got no clue of how to do it (SM-LK).

**SR15L5:** I just try (D-SE) even if I don't know the answers, I will just answer even if they are wrong, because I don't know. And I wouldn't want to leave them blank. Sometimes I just answer for the sake of answering because I don't know (SM-LK) what to write.

**SR15L6:** Sometimes I try (D-SE) even if I don't know the answer. But then if I really don't have a clue then I always leave it blank (SM-UN)

**SR15L7:** For the questions that I totally don't have a clue, I will always leave it blank (SM-UN). Just because sometimes I get stuck and there is just nothing that is coming into my head. But yeah, only on some questions, sometimes I try some questions

**SR15L8:** When I don't know the answer I try (D-SE) to think and if I don't know the answer I always leave the questions blank (SM-UN) because I don't know what to write.

**SR15L9:** Sometimes I try (D-SE) to think of what the answer is and what the question is asking about and sometimes if I don't know and I have no idea I will leave it blank (SM-UN)

**SR15L10:** Some I have to try (D-SE) and some I have to leave them blank (SM-UN) because I don't understand the questions (SM-UN).

## 6. What challenges do you encounter when learning graphs of motion?

*Find out their understanding of GoM concepts, and what makes them fail to make connections between graphical questions and real world which brings about difficulties in reading and interpreting graphs and these in turn causes poor performance.*

**SRI6L1:** I go to study in my book and to collect some question papers and booklets (R) so that I can revise I often find some questions that I don't understand. I also have a problem with textbooks (R) since we are not provided with text books.

**Follow up question 1:** Any challenges when it comes to answering those questions and if so what are those challenges?

**Follow up SRI6L1:** Challenges are like problems or what Ms?

**Follow up question 2:** Exactly, can you mention some or all of them?

**Follow up SRI6L1:** I have problems in calculations for example reading from the graph and when am calculating I use to get confused (C) and then I end up using the wrong formula (SM-C).

**SRI6L2:** The challenge that I have on the skills that I have to apply to the graphs, the skill is not enough because I cannot read on my own like after lessons because we are not given textbooks (R). Sometimes, let me say you are given to draw or plot a graph or something like that. Sometimes if I don't know which one should be on the x-axis and which one on the y-axis (SM-IA), in most cases I just leave such questions without answering them. And if there is a graph and you are asked to explain what is happening to an object at a certain point (SM-I), that one is a big problem to me because when I look at the graph I just see lines but then to tell the meaning of those line ayeeee I can't even if I think about that, I really can't just get it. And I will just leave it

**SRI6L3:** The challenges are, sometimes am not able to understand (SM-U) what somebody is trying to give me and I am not actually not getting it, I actually try and approach somebody else for example my fellow learners so that I can at least get something..

**Follow up question:** can you explain more?

**Follow up SRI6L3:** I for example in the summary, I look at the table and I try to do it (D-SE), to see if I can get the exact same answer as in the summary or go through the handouts that I am given by the teacher to see if I can do the activity that are given in the handouts. And the other thing is how to you use the graph to calculate (SM-C) and how to explain the graph (SM-I). I really have a problem of taking values and, may be calculate the area of the graph or the velocity.

**SRI6L4:** The biggest challenge that I am facing is the calculations (SM-C) when using a graph. Jaa, that's all

**SRI6L5:** Yes, somehow... maybe the graphs calculations (SM-C).

**Follow up question:** Ok, the calculations, so even looking at this answers here, for example section one questions 3, even just to choose the answer from there, the answer that you chose is wrong. And you are saying the challenges you are experiencing is mainly on calculation but then this questions does not require any calculation.

**Follow up SRI6L5:** May be my knowledge of graphs is not just good (SM-LK). I really don't know (SM-LK), in fact I just don't understand the whole topic, I don't understand graphs of motion, even in mathematics I am just failing. I have a problem with things that are from mathematics.

**SRI6L6:** We really don't have books (R). And Sometimes I have a problem, like when you are asked to calculate, let me say from a graph and you don't know where to find time and distance for example. I normally end up swapping the axes (SM-IA) and then as a result I will get wrong things.

**SRI6L7:** Yes Ms, for example when am given some questions and I have to answer them about distance acceleration etc. it is not easy at all.

**SRI6L8:** I struggle to find out like, if I am asked to find a certain distance between two things

**SRI6L9:** Yes, sometimes I seems to understand when I am learning but when I get in the exam room or when writing the test, I think like things are easy but, I write what I think is right but when the results are coming I will not get anything

**SRI6L10:** No, Yes, .....*gestures.... failing to express her self*

7. **What is your biggest challenge when answering graph of motion questions and what solutions do you suggest for to overcome those challenges?**

*Want to find out the major challenges faced by learners when answering/solving graphs of motion problems and also suggested ways that can be used to address those challenges.*

**SRI7L1:** I can get the time from the graph and I will calculate and the other thing is that I have a big problem of explaining what is happening on the graph (SM-I), for example I use to get confused when am looking at the graph and it is not straight, sometimes the lines are going up, sometimes are going down or even straight, I really cannot tell what is happening at every stage of the graph. If there are questions then I always get confused (C) and I will not answer the questions correctly.

**SRI7L2:** My biggest challenge is to explain the graph of motion (SM-I). When you are asked to interpret the graph, for example a velocity and distance time graph. Like what is happening at every stage of the graph that one I don't know how to do it (SM-LK). Even if I try to just study the graph and I seems to understand in the test I will always get it wrong.

**SRI7L3:** Actually, my biggest challenge is the one of using formulas (SM-C), like when we are talking of the distance or the displacement covered we look at the area under that graph. Now just to calculate the area, like which values should I use that's why in most cases I use the formula for calculating distance when speed and time is given but it is not the right one. But some other things are fine.

**SRI7L4:** Like when I am studying, I like to use or to check question papers and some books where there are graphs and some questions I try practising them to see if am getting them right or not. But I am always not getting them right even if I ask my colleagues and even them they don't know or maybe they don't understand them as well. I just can't use the graph (SM-I), I got no clue on how to use it even if I am taught. But I always deal with them (D-SE).

**Follow up question:** you deal with them.. and if you still get them wrong?

**Follow up SRI7L4:** If am still getting them wrong, then I go further and seek help from the teacher (TR)

**SRI7L5:** Ms, I just don't understand all the things (SM-U). Graph of motion itself is a challenge to me because I don't understand anything.

**Follow up question:** so what do you do since you have a wide range of problems on graphs of motion?

**Follow up SRI7L5:** I just try (D-SE) and read in my notes and then I will go through and try those examples and try again to see if I can get them or not.

**SRI7L6:** No, and also drawing like, let me say if you are asked to draw velocity ahh velocity decreasing with time or something, you don't know how the graph will look like (SM-I) for example whether it will be a straight line or the line is decreasing, constant, jaah all those things and this is the most problematic one.

**SRI7L7:** I like studying, like with a friend whom I know that he or she is better in case if I don't understand then I will get help from that person. But there are always things like calculations (SM-C) taking readings from the graph, explaining what is happening to the graph (SM-I) at different stages, I really have a problem with that. What we need to do I think is to watch the videos (SM-S). And you can also help me (TR) like using different graphs and explain them one by one

**SRI7L8:** The most one is just the calculation (SM-C) from the graph. Even if I try (D-SE) to answer questions by looking at the graphs and answer the questions, I will not get the correct answer. I think I only need to practice and study more (D-PR) or even get help from the teacher (TR).

**SRI7L9:** I normally practising past question papers that consider motion, but there are always question that requires interpretation of graphs (SM-I), those ones are tough you look at the graphs with different stages represented by lines, and you need to explain, I always find it difficult.

**Follow up question:** anything you can do to overcome those challenges?

**Follow up SRI7L9:** I will ask, like we study in a group (D-R), we ask each other how to do it, and if we don't have an idea we will keep quite or ask the teacher only in few cases

**SRI7L10:** *gestures.... failing to express her self*

## 8. What do you think will make graphs of motion lessons interesting and enjoyable?

*I would like to find out factors that they think will enable them to learn GoM better and also some strategies that will make the lessons interesting. Want them to enjoy the lessons by providing me with something that I should consider when planning the interventions as this might help the lessons to be more successful.*

**SRI8L1:** I think for us we need to do good things, we can even play games (SM-S) in class, ;like people moving fast, some moving slow and so on.

**SRI8L2:** What I want to be done, when we have free lesson than we can repeat the topic again. And find some possible ways for us to improve. After the lesson we should always go through different questions (SM-R) in order for the teacher to measure our understanding, if we are not progressing maybe we can even do the topic again. And because we do not have text books (R) may be you can give us a lot of handouts with graphs and calculation and other activities during the lesson so we can practice

**SRI8L3:** Actually I am suggesting that we should try and watch things like videos (SM-S) to see if they can help us in graphs of motion. We should also use real things (SM-PK) that are moving and explain them and see how we can relate them to graphs and we should take more activities to see if we can get more knowledge on graphs of motion. We should also get help from the teacher whenever we don't understand (TR). We should also help each other (D-R) as fellow learners from the school to see if we can accomplish this.

**Follow up question:** As learners how are you going to help one another?

**Follow up SRI8L3:** Yes, there I am suggesting that we should do group work or forming study groups with each other as this will help us more.

**SRI8L4:** Okay, they should do more activities (SM-S) on graphs of motion in groups, we discuss and give feedback. I really enjoy discussions because we use to be free unlike when you are talking to the teacher. We should like..... watch videos (SM-S) about graphs of motion and then get information and then maybe we also go on the net (R) and get more information on graphs of motion and report back on our findings.

**Follow up questions:** Ok, anything else?

**Follow up SRI8L4:** And maybe we can also consult the teacher (TR) and ask more questions (SM-SE) in case if we are struggling with graphs of motion.

**SRI8L5:** No Ms, I don't have any idea but I will accept anything that will come my way. As long as it will help me do better.

**SRI8L6:** I recommend that we should do just do more work (SM-S), we really need to practice more, we can also watch videos (SM-S), it will be very interesting (D-I) to have a lesson whereby we are watching TV and also go on the net (R) since these graphs are very confusing (C).

**SRI8L7:** May be what we can do is watch the videos (SM-S) and after watching the videos we can get activities and tasks and check if we really understand or maybe we need some more assistance again because I am struggling with Physics.

**SRI8L8:** I think we need to watch more videos (SM-S) on graphs of motion, do research like find out more about the graphs of motion on social media like computer. We can also play games (SM-S), I think games like some learners walking and we measure their distance and time will help.

**SRI8L9:** We should do more activities, watch videos (SM-S) and search on the internet other best strategies that can be used to learn graphs of motion best and how other people like in other country are doing it. Because graphs of motion is not easy, sometimes it is easy only that we learners we don't want to concentrate. When we heard that something is hard then we will also say it is hard, I wish we could come up with something that will prove to my fellow learners that graphs of motion is not hard

**SRI8L10:** No, anything that will allow us to do better

## APPENDIX H: TRANSCRIPT OF LESSONS OBSERVATIONS AND CODING

### Lesson 2: Introduction of kinematics concepts (2h30 minutes)

I started the lesson by introducing the critical friend and her reason for attending the lessons with us. I also reminded the class the purpose of the lessons and appeal to them to be free during the lesson. By looking at their facial expression I can see that they were happy.

I started by introducing the lesson, whereby I mention that “*our main aim for this lesson today is to look at graphs of motion*”. Before beginning with the actual presentation of the lesson, I asked the learners to state what it meant by graphs of motion (PK). The reason was to see if they can still remember what graphs of motion is and what it involve from the lessons they had during the first trimester. Some learners were seen paging through their note books looking for the answer to the question. The following was L5 response

*L5 – it is a table showing the movement of an object, for example, such as the acceleration or deceleration of an object.*

This shows some confusion (C) on some learners faces and I have to ask them for clarity as to whether graph is a table or not.

*L2- it is a diagram*

*L3- it is a sketch*

*L4- it is a drawing*

*(The above learners responses shows the way they graphs of motion to different semiotic forms)*

After getting those responses(SM-CM) I then explain what GoM as *a drawing that show the stages of a different stages of an object movement*. This was followed by the actual presentation of the lesson by introducing distance and displacement. I asked them to state some other concepts that are linked to graphs of motion apart from distance and displacement whilst writing them on the chalkboard they stated *velocity, speed and acceleration*. I then led them into the explanation and definition of those concepts. I further explained and emphasise that “*these concepts are the ones that we need to know whenever we are learning graphs of motion*”.

After explaining the concepts, I read out and explain the objectives of all the lessons (intervention) as highlighted in the NSSC syllabus.

- *Interpret the graph to identify when a body is at rest, moving with constant or changing speed*
- *Identify linear motion for which the acceleration is constant or not constant*
- *Calculate acceleration for motion with constant acceleration*
- *Use the area under the graph to determine distance travelled by an object*

## Lesson part A: Distance and displacement

I started this part of the lesson by asking learners to define distance and displacement in their own words (SM-PK). After thinking for sometimes

L6: *distance is the distance between two points*

T: *can you please explain more by distance is the distance, there is a repetition in your answer..ah distance cannot be a distance again.... What is the proper word that we can use to define distance?*

L6: *is the physical distance between.....*

Some learners raised their hands (D-R) to give the answer

T: *yes dear*

L4: *distance is the physical separation between two points moved without considering the direction*

L7: *distance is the separation between two points*

T: *very good, and what about displacement?*

L7: *displacement is the distance in a given direction*

T: *wow, interesting let's look at the power point*

The class discussion was followed by a power point presentation which includes pictures and drawings (SM-S) showing the differences between distance and displacement. I used a picture of a mouse and cheese to demonstrate the distance travelled from where it was to the position of a cheese and also the displacement covered by that same mouse to get to the cheese (SM-CM).

To explain the difference between the two concepts, to make sure that learners understand (SM-U), I asked them to tell me how the diagram shown on the power point explain distance.

L3: *there is no direction covered only the actual distance from the mice to the cheese*

L2: *it is longer because it is not a straight line. (SM-CM)*

I further explain that the same diagram can still explain displacement since we can still get the straight short distance from it. I further added that displacement shows direction as to whether the object is going south, east, west, north, up, down and so on. Learners were shaking their heads (SM-G) and this gave me an impression that they are on the right track.

This was done to make learners understand more (SM-U) and be able to differentiate between distance and displacement(SM-D) as well as making sense of distance and displacement.

Apart from that, I also used the diagram showing the perimeter of a rectangle to explain the difference between the two concepts.

After the explanation of using the mouse and the drawing of a rectangle, I could tell by looking at the learners faces that they were able to sense something (SM-G) as it was explained to them in more simple terms and with the use of the images and or representations (SM-S). This was followed by an audio-visual on distance and displacement and learners' were asked to identify key features (SM-IP) that differentiate distance from displacement. Features identified by learners were: *no direction* and *scalar* for distance and *direction* and *vector* for displacement.

The representation, illustration and the audio-visual enable the learners to explain the difference between distance and displacement better through the use of pictures and symbols (SM-S). Learners were then asked to explain (SM-SE) the difference between the two concepts by looking at the graphical representations.

L3- *"distance only shows magnitude and the unit and displacement shows distance, magnitude and unit"*

I further probe them with more questions after realising that learner 3 cannot differentiate distance and displacement correctly for them to explain again.

L4- *"distance shows direction whilst displacement does not show direction".*

I then ask learner 4 to explain it further by looking and pointing at the mouse and cheese on the picture. Learner 4 was looking a bit puzzled and uncomfortable (C) and as a teacher I tried to explain it again, step by steps, slowly but surely pointing on the picture of a mouse and the cheese. I stated that

*"the distance is when it goes through all that way up to where the cheese is ( showing on the diagram) and displacement is when there is a short cut, this short one and it is always a straight line, look here, it is straight from her up to the cheese".*

I then asked them to re-explain it using their own words (SM-U) looking at the picture of the mouse and the cheese

L3- *"distance is a scalar because it separate the mice from the cheese and no direction is considered because it goes in different direction"*

And displacement? A different learner raised

L5 – *"is the physical length that is between the mice and the cheese and it is always that straight distance".*

The teacher ask if they were having questions but some with smiling faces (D-P)they indicated that they don't expect for learner 5 whose hand was raised high up (SM-Q).

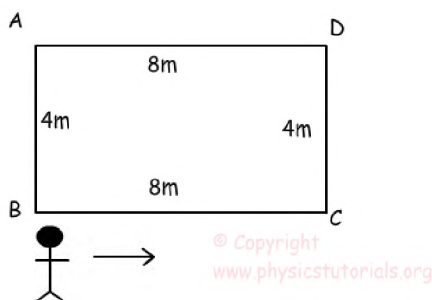
L5- "do we always have to write the, the direction where the thing is going when talking about displacement?"

My response was: "Yes, for displacement, you should always give the direction, otherwise if you did not write the direction then it will be like distance"

L5-"but in textbooks they are all indicated in a similar way, for example when there are drawings".

The learner argument was based on what is currently written in some Physical Science textbooks being used in Namibian schools. I then explain that it is just a fallacy that is in the books and this is why we should have a clear understanding when it comes to these concepts.

Let's look at how we can calculate distance and displacement covered.



T: We have a boy travelling from here (starting point B) to C and then from C to D and from D to A and from A to B. What is the distance travelled by the boy?

L4: the distance is 24 m Ms. (shouting the answer after doing some calculation in her book) (SM-C)

T: Class? Can we all see where the 24m came from?

Some learners were still quite busy working out their answers.

L9: yes Ms.

T: how did we get 24m?

L9: I just add all the numbers together because they give the total distance (SM-C)

T: so the boy is from B to C to D to A and then back to B. so, what is the initial point?

Class: the initial point is B

T: and the final?

Class: still B

I explained that the initial point is the same as the final point. So this means that the displacement is zero, because it's like there is no displacement because the initial point is the same as the final point. He started at B and stills and at B. if you are to look at the straight

distance in a given direction then there is nothing. Learners were also seen taking notes, some paying attention, nodding their heads (SM-G) as I was explaining.

## **Lesson Part 2: Speed and Velocity**

This part of the lesson was mainly on differentiating speed and velocity. The lesson started with learners watching about three videos showing speed and how to calculate speed of a moving object. Before playing the videos, I asked them to differentiate between faster and slower speed. *“quickly discuss with a person who is next to you. You have two minutes”*

L5: *We can tell by looking at the time taken for an object to reach a certain point*

T: *yes, what else do we need to consider? What should we look at? Yes, pointing at learner 1*

L1: *you also need to look at the distance covered*

T: *good, let's look at the videos and see if we will be able to tell who is fast and who is slow.*

The videos allow learners to be able to see simulation of moving objects and therefore will be able to develop a better understanding (SM-U) of what it means by speed and velocity and how best they can be differentiated from one another.

The videos were watched one after the other, pausing them after few minutes play and explain in details by incorporating learners prior experiences (SM-PK) according to what is happening in the video, pose some questions (SM-SE) as this will allow learners to think and make sense of the concepts.

Examples, let's look at this *“the distance covered by the boy to move from point A to B is two minutes, the distance covered by the man from A to C is two minutes again, in this case, same time is used to cover different distances, now who has more speed? The boy or the man”*

L8 – *the man, because greater distance is covered as compared to the boy in short amount of time”*

I asked if they could you give me another example of object speed whereby we have object moving faster or slow from our everyday life (SM-PK)?

L3- *“for example when there is athletic at school, the winner is the runner who is fast because the winner took less time to complete the same distance”*

As a teacher, I further explain what it means by a fast object and slow object in terms of distance covered as well as time taken (SM-D) to cover a certain distance taking into consideration what was mentioned earlier by learner 1 and 5. In addition I also explain the difference between a uniform speed and non-uniform speed, uniform and non-uniform velocity (SM-D) and relate this to the reason why learners are required to wear uniforms at school (SM-PK).

I further ask learners to give other examples

L7-*“uniform and non-uniform can also be explained for example if there are people driving. Like when people are driving on a high way they drive with uniform speed unless if there is something on the road and if they are on a busy road then they drive at non-uniform speed and then there they have to change gears so many times resulting in a change of speed”.* (SM-PK)

I then explained the difference between speed and average speed adding to what the video demonstrated on the difference between the two. I asked them to ask questions and they demonstrated that they understood everything.

T: *ok that's great, now tell me the difference between speed and average speed and when can we use them, pointing at learner 10 who has been quite throughout the lesson.*

L10: *speed at that time*

T: *which one is that? Speed at that time?*

L10: *the normal speed Ms, like speed at that moment*

T: *and average speed?*

L10: *is when you have more than one speed*

T: *could you please try again? Try and explain more*

After seeing that learner 10 was struggling to explain (SM-U) the term average speed so I ask somebody else to help

L6: *that's when we have an average speed of many speeds added together.*

I then asked them to discuss in pairs (D-R) the difference between velocity and average velocity (SM-D). Since they were only two it was difficult for them not to participate, the whole class was now filled with discussion vibe, all the students were talking at the same time (D-R) and for me to hear what they were saying I have to move table by table listening to their discussions and helping them clarify some stuffs.

The following are some results from the discussion on what velocity is

*Velocity is speed in a given direction, velocity is displacement with time, some learners include time which was true for velocity and some defined it without time and this was a misconception. velocity is the displacement covered in a specified direction, velocity is a straight distance in a given direction,*

I then have to clarify that when we are talking of velocity we must always include time.

T: *For average velocity*

*Average velocity is the total displacement in a given time*

I highlighted that the SI unit of time is second denoted by small letter s and for distance is meter denoted by small letter m. *so what is the basic unit of speed?*

They all answered at the same time: *meter per second (m/s).*

*T: And for displacement?*

*Meter per second including the direction (m/s) + direction.*

To engage learners more with the content, more especially when it comes to the calculations of speed and velocity, I demonstrated a simple way of drawing a triangle that is separated into three parts where one have to cover the concepts in order to get the formula for calculating speed when given distance, time and vice-versa or calculating velocity, when displacement and time is given. This enable the learners to get the formula for calculating speed and velocity without struggling more with them. This also enable learners to have a clear understanding of the difference between speed and velocity (SM-D) in terms of calculations (SM-C), practice and the theory part.

To end the discussion on speed and velocity, gave them worksheet on speed and velocity to discuss in groups. During the discussion they were seen interacting with one another (SM-CM), inquiring (SM-SE), writing answers and explaining to one another (D-R) as the discussions went on in their groups. They were really active throughout.

Towards the end of the lesson, worksheet to differentiate distance and displacement were also handed over to the learners in order for them to apply the skills (SM-CM) they have learned throughout the lesson to answer the questions.

*T: you are only expected to complete the first part of this worksheet. I will tell you what to do with the rest of the worksheet later.*

The whole class responded, ok Ms. They were seen engaged fully each on his or her own desk applying the skills learned throughout the lesson to answer the questions. Some learners were seen scratching their heads, biting off their nails and holding the back of their heads (SM-G) several times an indication that they were struggling to answer the questions. To make sure that learners were fully engaged in the activity, I then moved around the class and provide support when the need arise and also just checking if they are on the right track, for example constructing meaning when applying skills learned during the lesson (SM-CM). If they were not on track, I then asked to re-do it again. After completing the activity learners share their answers (D-R) with the whole class.

### Lesson 3: Drawing kinematics graphs (1 hour)

The focus of this lesson was mainly on how to draw different graphs of motion. We started this lesson by giving feedback on the activity of distance, displacement done the previous day. During the feedback, my emphasis was mainly on the specific challenges I have encountered while marking the activity papers and how best they can work on them. Some of these were writing answers without units and leaving some questions unanswered.

*“don’t just write numbers there without stating or writing the units. The units must be there always and please always try your level best, you will never know if you are right or wrong only if you happen to try. Don’t ever leave questions unanswered”*

The learners watched the video on how to draw a distance vs time graph and move from a distance time graph to a speed time graph. The two videos explained simple examples of how to draw distance time graphs from objects that are covering a certain distance in some amount of time. The first video was on how a squirrel changes position in different amount of time by moving forward and away from the tree (which is taken as the origin) and plot a graph as the squirrel moves forward and backwards, toward and away from the tree. The second audio visual was of the “walking man”, a simulation that was created by the University of Colorado to explain the distance moved by a moving man and how best it can be represented on the graph to make learners understand how to draw and explain graphs of moving objects.

I further explained that when drawing a graph there is always a zero mark (origin) that should be considered. The graph explained was from the information presented in the two videos (the information of the squirrel moving towards and away from the tree, and the walking man moving forward and backwards).

By drawing a graph and show it to the learners on the chalkboard, I then explain how the graph depend on the starting point of the squirrel (SM-SE). In this case it was at 2m. When the squirrel moves from 2m to 5m it took 7s and this is clearly shown on the video, I then explain by illustrating on the chalkboard. During the process, I can clearly see that learners were getting something, meaning that what I was explaining made sense to them and this is where I observed the “*ahaa*” (D-PA) moment showing that learners were getting an idea of how to represent the information on the graph.

Learners were looking amused (D-P) and one of them ask that “*but how does one draw a graph, just joining lines and those lines represent something?*” (SM-SE) I then explain that

*“a graph is not drawn from nowhere but it is from somewhere, it is always from somewhere and the somewhere in this case is the squirrel that is moving towards and backwards covering certain distances in some amount of time, a graph is actually something that represent the journey of an object”.*

A sense of confusion (C) was observed on learners' faces and to clear that confusion I have to go back to the audio visual and explain all the stages of drawing graphs step by step. I observed a moment of silent (D-CN) in the class and this was an indication that learners were really having a problem of demonstrating/showing/ representing the movement of an object on a graph because some were even saying "*the velocity on the graph is increasing*" whilst the velocity was constant. This was then followed by a discussion (D-R) whilst watching the video, as I have to stop the video, demonstrate by drawing on the chalkboard and attend to their questions one by one.

L6- "*now how will I know that the slope on this graph represent speed or velocity or acceleration?*"

I explained this by taking learner 6 back to the first lesson when I introduced graphs of motion concepts by defining each and every concepts and shows which one are scalar and which ones are vectors and why they are regarded as such. This then brings us to the issue of explaining the slope on each graph, if it is a distance time graph then the slope gives the speed, if it is displacement time graph it is velocity and if it is a velocity time graph then the slope gives the acceleration and this can be calculated by looking at the rise over the run on the graph.

While watching the video, I stopped it and ask some questions. "What is the meaning of the slope on the distance time graph class?" yes, give me the answers please, what does the slope indicates?

Class: *it gives the information about the moving object.*

T: *yes, we know that it gives the information about an object that is moving, can we please be specific*

L7: *it gives information about the distance*

T: *no no no no no... this is a distance time graph, there is no way a distance time graph can give distance. What does it give? The word starts with an S..*

Class: *ohoooooo, it gives the speed of an object.*

T: *ok, what if it was a velocity time graph, then the slope gives*

L8: *then it gives speed*

T: *distance time graph gives speed, velocity time graph also gives speed. Use your mind please, okay?*

L5: *I think it gives the acceleration of an object.*

During that, I have realised that learners were not feeling comfortable, some were holding their cheeks and looking so helpless (D-CN) when we are talking of slopes on graphs. Some cannot even identify which one is a slope and which one is the area under the graph. They took them as the same thing.

T: *"please ask questions, look at the video and if you see something strange, ask, don't keep it to yourself"*

L6: *Now Ms, tell me the difference between the two slopes, the one that is going up and the one that is going down on the graph? How will I know this slope gives what, I am confused. I don't know what is happening on those graphs. (SM-SE)*

T: *class. Let's help her out here (whilst pointing on the graph), what is the difference between the two slopes? What do they give?*

L8: *since it is a displacement time graph, I guess the slope gives the velocity of that object.*

T: *yes, very good, this is wonderful!, it gives the velocity but what makes the two slopes different? Somebody to help with the explanation? Learner 5 hand was high up, with a lot of confidence in him (D-CN)*

L5: *the one that is going up shows a positive velocity and the one that is going down gives a negative velocity*

*That's it. It is clear now or should I explain more?*

L8: *no Ms, it's fine, soo it is just like acceleration and deceleration... I got it now (whilst nodding her head). (SM-G)*

I provided them with a rise/ run formula so that they can calculate the velocity from a displacement time graph provided. Whilst they are doing their calculations I walked around the class and offer them support by helping them to find the required values on the graph in order for them to do the calculations to find the velocity covered in 5s. I further explain that if there is no displacement then the velocity is zero and this is the same as when the distance covered is zero which gives zero speed.

Whilst I was walking around I have noticed that some learners created their own formulas which are far from the one that is provided and this leads them to wrong calculations (SM-C). *"You don't pay attention at all"*. I then warned them not to create their own formulas but to use the one that is provided and I also guide them on how to use the formula to get the values that are shown on the graph and ask them to use the calculations on the chalkboard.

I encouraged them to ask questions and one of the questions asked by the learners(SM-SE) was:

L5- *"how different is calculating velocity and speed from the graph like from a distance or displacement time graph when there is no distance or displacement covered?"* My response was that if there is no distance or displacement covered then there is no speed or velocity.

L4: *how about calculating displacement from a velocity time graph? Is it the same as calculating distance from the speed time graph since it have the direction?*

T: *for that we use the same formula, why maybe? Class?*

L10: *displacement is the same as distance, so you need to calculate the area.*

T: *which area are you talking about?*

L10: *the area under the graph, or the area of the slope.*

T: *you can use the area under the graph considering the shape and you can use the formula of that shape to calculate the area.*

I further explained that, *if the area under the graph is a rectangle for example, then you need to use the formula for calculating the area of the rectangle which is? Whole class: length times breadth (lxb).* Yes very good, it is just like that, for every shape you use the formula for calculating the shape of that area.

#### **Lesson 4: Graphs of motion interpretations (1 hour)**

The lesson was on graphs of motion interpretations. I ask them to give a review of the previous lesson which was on drawing and differentiating different graphs of motion. I then ask learners to divide themselves in groups of three for them to discuss (D-R) and interpret graphs of motion when they are provided with different types of motion graphs.

Before the group work, learners watched the video showing how to interpret distance versus time, speed versus time and velocity versus time graphs in one dimension (SM-I). This was followed by a discussions, explanation and clarification on how to interpret different graphs of motion by highlighting the key feature that one should look at.

Learners were assigned to interpret different types of graphs e.g. distance versus time graph, displacement versus time graph, speed versus time graph and velocity versus time graph. The main aim was mainly to see whether learners are able to interpret concepts (SM-I) and construct meaning (SM-CM) when presented with different types of situations.

After watching the video, I then handed out the worksheets on graphs interpretations.

*"I want you to discuss and not just to write down the answers, with complete sentences. Don't just write items there because you are going to report what you have discussed".*

Learners were seen discussing but there were some who seems to be working individually in their groups although they were supposed to discuss. *Are you discussing? Yes Ms, says the whole class.*

I then noticed that some learners were just saying yes but then they were not doing what we were supposed to do (D-CU) and I had to make it clear to the whole class so that we can all do the same thing.

Group 1 members: *then we have to give a reason neh (showing on the handout)?*

*No that one must be an A.*

Group 2 members: *is that not m/s?*

*No, there are two seconds, look at this one and the other one again. They are two*

*So it is m/s/s and then it will give m/s<sup>2</sup>*

*Yes it is like that. It is the velocity squared mos, hasho (translated-isn't?)?*

*Ayee.. it is the acceleration not velocity squared.*

Group 3 members: *which shape fits a distance time graph of an object moving at a constant speed? Shuuh this question, also says one learner from the group*

I intervene because I saw that they were struggling to interpret the question. Ok, look here, let's take this as an example. If this graph is going into that direction, then there is no distance that is covered. This object is not moving but they are asking of an object that is moving at a constant speed. Please try and discuss this, look at the question and scrutinize the graphs (*some were nodding and some were shaking their heads after that explanation and they all started to smile*) (SM-G).

Group 4 members: *this one is a distance time graph, and a distance time graph is supposed to be straight but this one forms a curve (they all started shaking their heads. She stated further that if we are to look at this graph, it is saying the object is, moving in a straight line, meaning distance is increasing with time. Ohoooo, so when distance is increasing time is also going up on the other side mos. Yes, I think it is like that. Yes, the the graph must be straight because both of them are going up. (D-R)*

Looking at the expressions on the faces of the learners in this group, they were so happy and they were enjoying the discussion.

Some learners were seems not to have an idea of what the discussion is all about. I then have to walk through group by group and giving help where it is needed. After the group discussion, learners were given a chance, group by group to present what they discussed in the group.

When it was time to report back, some learners were still not done as they were seen still busy discussing.

Group 1 presented their findings first. *One learner in the group was brave enough to presents their findings but then she was not so comfortable to present. (D-CN)*

G1L: *What does the slope of a distance time graph indicate about an object motion? The answer is that it determine the speed of an object, and the slope of a velocity time graphs shows the acceleration of the object.*

*Class are those answers correct? Yeeees, whilst clapping hands and looking soo happy. The presenter went back to her seat smiling (D-P) all the way.*

There were some instances when the learners were totally failing to present their findings (D-CN). In such cases, I have to guide them during their presentations, for example one learners when trying to answer the following question “*which shape is the shape of a distance time graph of an object moving at a constant speed?*” a learner stated that, “*in a distance time graph when speed is, when distance is low, because there is no, because when an object is moving, but when in a distance time graph there is no movement ( the learner was lacking confidence and she was not so sure of the explanation she was making).*

*T: because when the object is moving in a distance time graph there is no movement and you talking of movement? Anybody from the same group to help us with the correct answer? The remaining group members were all looking at each other (SM-G) and I have to divert the question to the whole class.*

*L5: constant speed on a distance time graph is shown by a straight line.*

There were some learners who were struggling at first but with the guidance from other learners in the group (D-R) they managed to get the correct explanation of what is happening at different stages on the graphs.

### **Lesson 5: constructing graphs of motion and solving graphical problems (40 minutes)**

The lesson was on discussing graphs of motion and how to interpret them and best ways of solving graphical problems. This lesson was just a revision type of lesson where I combined questions and discussions from all the other lessons covered previously and give learners different graphical problems to solve in pairs with the help and guidance as they discuss with one another and solve the graphical problems. Before starting with solving graphical problems, I allowed them to ask questions about things they are not sure of (SM-SE) and the watch parts of the videos that are showing the problematic area.

*L10: when looking at the graphs, sometimes they are talking of a steeper line and sometimes they are talking of a line that is not steeper. What is a steeper line and what does it show?*

*T: if we are talking of a steeper graph then we are referring to a faster object, that means that shorter distance is covered in little amount of time and if it is not steeper then the object is slow (explaining whilst showing the steeper and non-steeper line on distance time graph).*

Learners were asking thoughtful questions and this was a good sign because this allow them to think and create meanings before reporting back to the whole class (SM-U).

Learners were really involved in the discussion and they were debating with their partners each and every one trying to defend his or her point (D-R).

Looking at the velocity versus time graph and distance time graph at the same time, a heated debate was heard as they were trying to prove their understanding.

L7: *on this one there is no straight line indicating whether the object is standing still or not.*

L5: *and this line, what is it showing?*

L7: *that one is showing that the object is moving.*

L5: *a straight line is not the only one that shows that an object is moving or not. The line can also be a bit curved as long as there is an increase on both axis the object is just moving.*

Learner 7 was now showing some funny facial expressions (SM-G) showing that he agreed with learner 5.

As I was moving around the class I joined one discussions and I had to ask them questions relating to what they were discussing.

T: *what name is given to negative acceleration?*

LL: *a negative acceleration is called a deceleration.*

T: *okay, so what is the acceleration at that point?*

LL: *it is zero*

T: *but why? and please don't tell me that it is because velocity is constant*

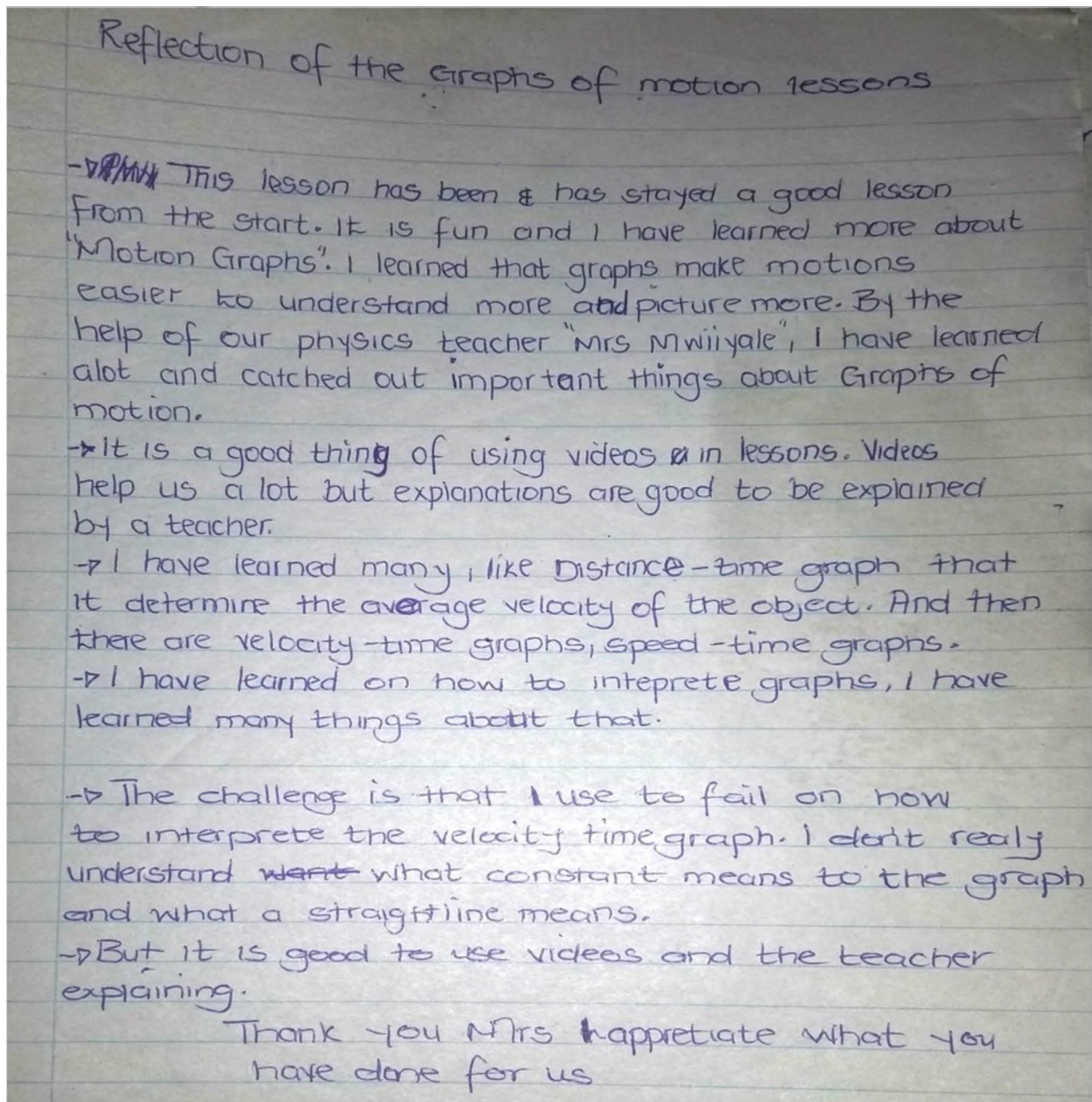
L9: *I am not sure, may be it is because it is not changing or (holding her mouth) (SM-G)*

T: *there is no change in velocity so the acceleration is zero.*

The discussion was interesting (D-I) to some learners but there were still some others who cannot answer the questions confidently.

## APPENDIX I: SAMPLE OF LEARNERS' REFLECTIONS

### Reflections 1



## Reflections 2

### REFLECTION OF THE LESSONS

It was a great moment having such lessons. The lessons went on well and all was well throughout that time. Even though they were short they were fascinating, usefull and they were also enjoyable. I got no regret on having such lessons. They changed my performance on graphs of motions. At first I didn't understand well and couldn't answer some questions on that topic but now I am getting at that point of getting everything well on that. I really appreciate that. Gaining knowledge and knowing more about a certain thing in life is the best thing. I am proud I gain some knowledge and I know more about graphs of motions

I really appreciate everything. I am proud I'm now unique simply because I believe I got more knowledge and I now know more about graphs of motions that I was struggling with. It was blood, sweat and tears but it later got to the point of excitement. I learnt how to answer questions on acceleration, velocity and distance graphs. I learnt more about speed itself and speed graph. Hoping to get more on this since they are really helping

I appreciate all this so thumbs up.

### Reflections 3

The lessons were very enjoyable, before I would like to say thanks to <sup>you</sup> my Respected teacher Ms. Mulyati for ~~giving~~ <sup>taking</sup> a privilege to ~~you~~ provide me with those extra lessons. I gain more from those lessons, they were all about "Graphs of motion", that become now my best topic among all topics in physical science. I am feeling proudly to received ~~a~~ such knowledge. Actually ~~a~~ I could not differentiate between position time graph and a velocity time graph, for ~~it~~ now everything is going ~~through~~ smoothly, <sup>Its</sup> ~~what~~ <sup>so</sup> a helpful. If I happen to compare those lessons with ~~a~~ flowers ~~this~~ <sup>those</sup> flowers were colourful. I knew now how to calculate acceleration on a velocity time ~~g~~ graph and how to read a distance covered on a velocity time graph. I also learned ~~to~~ that the slope on a velocity time graph shows <sup>acceleration</sup> ~~distance~~ and an area under the slope shows a distance ~~covered~~ covered, I ~~ka~~ never knew it.

## APPENDIX J: TURNITIN SIMILARITY REPORT

### MEd Thesis final

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#### ORIGINALITY REPORT

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