

**PHYSICAL SCIENCE EDUCATORS' AND LEARNERS'
PERCEPTIONS ON THE CONTENT KNOWLEDGE AND
CONCEPTUAL UNDERSTANDING OF GRAPHS IN ALGEBRA AND
KINEMATICS**

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DECLARATION OF INDEPENDENT WORK

DECLARATION WITH REGARD TO INDEPENDENT WORK

I, ITUMELENG BARNARD PHAGE, identity number ##### and student number #####, do hereby declare that this research project submitted to the Central University of Technology, Free State for the Doctor of Education in Science Education, is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself or any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

SIGNATURE OF STUDENT

DATE

DEDICATION

This study is dedicated to my late grandmother, Keorapetse Boneneko Phage, who has instilled in me the value of education, hard work, and dedication. I also like to dedicate this study to my late son, Letlotlo, my late mother, Kenaope Neriah Koikoi, my late brother, Penga, whom I have never met, my late uncles, my late aunts, and all those who left this world but cared and changed my life. With this I would like to rejoice in spirit as you have protected me to reach this achievement and you will continue to protect and give me strength all days of my life.

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ABSTRACT

Studies have been done on the students' understanding of kinematics graphs and kinematics. Mathematics has also been investigated to be the language and tool of learning physics. This means it will be difficult to comprehend physics without sound knowledge and understanding of mathematics. The poor performance of undergraduate physics students has been blamed for their lack of high school learners' knowledge and hence on their physical science educators. The study mainly investigated the perceptions of the high school physical science teachers on this blame and the poor performance of their learners in kinematics. A mixed method approach was used to collect data through a questionnaire and open-ended questions which were distributed to available sample of educators. After analysis, the results indicated that high school educators were also blaming their learners' lack of proper algebraic prior knowledge and the learners' inability to understand to apply and or relate to conceptual knowledge and problem solving in kinematics. The results also indicated that most learners, from their perceptions, lack the knowledge of algebra to use in kinematics, their ability to use and apply algebra graphs to solve kinematics graphs, lacked prior knowledge of algebra and kinematics from previous grades, passed the previous grades without conceptual understanding. The study concluded that there is a need for intervention strategies for these educators, even in lower grades, to be able to assist their learners in their poor knowledge or the lack thereof and the inability to apply that knowledge and skill in comprehending conceptual skills in algebra and kinematics graphs.

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Chapter 1: Introduction and background to the research

1.1 Introduction and background to the research

The lack of conceptual understanding in mathematics and physical science as well as high school subject knowledge seems to be the main cause of the high failure rate among first-year undergraduate physics students (Semela, 2010). One of the physics content knowledge areas that beginning physics students appear to be struggling with is the usage and application of kinematics equations and graphs., even though their high school curriculum teaches them this (Phage, Lemmer & Hitge, 2017).

Research from previous studies has indicated that experienced instructors and researchers in physics state that there are serious gaps in the first-year physics students' understanding of various topics, including kinematics graphs (Small, Rowe, Godfrey, & Paton, 2012, Brinkworth, McCann, Matthews, & Nordström, 2009, McDermott & Redish, 1999). Ramnarain & Molefe, 2012 have stated that from previous studies, there is also an indication that many introductory physics students fail and are unable to pursue such studies because of the lack of readiness of high school students to embark on such studies. As a result, Grade ten (10) to twelve (12) educators tend to be blamed for their poor performance in introductory physics studies.

The Curriculum and Assessment Policy Statement (CAPS) for Grades 10 through 12 in Physical Sciences (DBE, 2011) states that a learner-centered approach to the delivery of teaching and learning techniques is necessary for science education. (DBE, 2008), an inquiry-based mindset and practical activity skills are developed in an active and constructivist learning environment. (DBE, 2008). Learning will be built on a foundation of critical thinking and problem-solving skills. Thus, it is imperative or rather urging those educators who work with high school learners to develop critical thinking and problem-solving skills in them. By doing this, learners in grades 10 through 12 will be appropriately equipped to pursue higher education studies, utilizing their high school education knowledge to acquire new concepts and ideas at higher education and learning institutions (HEIs).

1.2 The research problem

The study is prompted by the inability [of high school exit learners](#) to use content knowledge and conceptual understanding of algebraic graphs (Phage et al., 2017), to represent, analyse and interpret kinematics graphs (DBE, 2011). This research is also due to the perception of teachers and learners that they appear to be having difficulties in physics concepts (Retnawati, Arlinwibowo, Wulandari, and Pradani, 2018; Daud, Karim, Hassan, and Rahman, 2015; Ploetzner, Lippitsch, Galmbacher, Heuer, & Scherrer, 2009). Research has been done to explore the ideas of high school teachers and their difficulties (blame, Duit., 1991) with graphs in algebra and kinematics. They further investigated how to help learners have a better conceptual understanding of the physics concepts perceived to be difficult. The problem being addressed by this study is the perceived difficulty of teaching and learning using the content knowledge and conceptual understanding of algebraic graphs in mathematics to solve problems in kinematics graphs in physical science subject.

The process of translating knowledge by educators among physics and mathematics plays a vital role in deciding the support from mathematics and assist them to create some new teaching methods that will enhance to defeat learners' difficulties (Moyo, 2020). Understanding the concepts in physics, in particular kinematics, will form the basis on which to construct new physics knowledge. In his study of the nature of learners' difficulties with mathematics in the learning of kinematics, Moyo (2020) discovered learners lack to simplify equations, to determine the square root, to make the subject of formula, to factorise, to solve fractions, to subtract and divide positive and negative values or variable mainly useful in kinematic motions. The symbols and terminologies in kinematics made it difficult for them to relate to algebraic variables and terms (Phage, 2015; Phage, *et. al.*, 2017; Moyo, 2020).

They both argued that this led to the difficulties in interpreting, analysing even sketching of kinematics graphs. While Phage (2015) recommended that physics educators should be able to refer learners to their prior learning about algebraic graphs, Moyo (2020) recommended that regular training and developmental workshops should be conducted for in-service educators in both mathematics and physical science. This he said, also confirmed by Phage, *et.al.*, (2017), will be to ensure educators are resourced into to be able to deals with related concepts in algebra and kinematics, hence improving the learners' conceptual understanding, gain

confidence and competence in both subjects, and finally enhance their performance in both subjects.

Learners from high school in their introductory of undergraduate study enter university with a hope of learning new concepts (Darling-Hammond, 2012). However, lecturers expect these students to use the previous knowledge or learning to embed new knowledge. It is therefore of pivotal importance that introductory undergraduate students should be able to use and apply their previous knowledge from high school to their new learning or maybe integrate that previous knowledge into the new knowledge.

The early learning of introductory physics at university, its application and use, is in the problem solving in kinematics. Interpretation and analysis of kinematics graphs and equations in the experimental laboratory report writing using linear functions and graphs is a predominant activity in the first-year introductory university physics. Now, the role of grades 10 – 12 educators or teachers in enforcing or imparting this knowledge among learners is very important (DBE, 2022). The way they teach or apply their teaching strategy in the knowledge and understanding of kinematics and application of algebraic graphs to their learners have significant and detrimental role in how learners use and apply that knowledge and understanding in their future learning even at undergraduate learning level and so on.

It is therefore important to investigate and get perceptions of these teachers on the learning and teaching of equations/ functions and graphs in kinematics. Applications and use of algebraic functions and graphs plays an important role in the understanding and knowledge of kinematics equations and graphs as well as solving kinematics problems (Phage, *et.al.*, 2017; Phage, 2015; Bektasli & White, 2012; Planinic, Milin-Sipus, Katic, Susac, & Ivanjek, 2012; Tebabal, & Kahssay, 2011). This is more anticipated in the interpretation and analysis of data or results obtained in physics laboratory experiments.

1.3 Aim of the study

The aim of the study is to investigate high school physical science teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics.

1.4 Research Objectives

The objective of the study is to investigate:

- the perceptions of physical science educators and learners on the content knowledge and conceptual understanding of graphs in algebra.
- perceptions do high school teachers have on the teaching and learning of algebraic graphs in kinematics.
- whether physical science teachers can relate the concepts in algebraic graphs and equations with concepts in kinematics graphs and equations
- national policy guidelines regarding-the teaching and learning of kinematics and algebraic functions and graphs.
- the background of physical science teachers has on the teaching and learning of kinematics and algebraic functions and graphs.

1.5 Research questions

- What are the perceptions of high school learners and teachers on the teaching and learning of graphs in kinematics?
- Which perceptions do high school teachers have on the teaching and learning of algebraic graphs in kinematics?
- How does physical science teachers relate the concepts in algebraic graphs and functions with concepts in kinematics graphs and equation?
- Do the national policy guidelines say anything regarding the teaching and learning of kinematics graphs in high schools?
- How does the background of high school physical science teachers impact on the use and applications of algebraic graphs and functions to solve kinematics graphs and equations?

1.6 Significance of the study

The study sort to increase the capacity and interest in kinematics graphs among teachers and learners so that learners have life-long knowledge they can use at tertiary level as expected. This will bring and build confidence among teachers and students to use share and relate ideas and concepts in kinematics for themselves and with each other. The teaching and learning of kinematics graphs using the knowledge

and understanding of algebraic graphs in mathematics in high schools will be enhanced. The fear and phobia of teaching physics as well as the lack of competent and confident physics teachers in high schools will be greatly reduced. Physics teachers will also be able to interact with learners and their fellow colleagues with confidence.

The study also carries a vital significance in that it will reflect on the views of other researchers on the perspectives of teaching learning of kinematics using algebraic knowledge. This will assist the learners to be equipped with better insight as to when and how to use algebraic knowledge to understand and perform well in kinematics. The physical science educators will also be equipped with pedagogical and epistemological skills to variate what trends are required for learners to understand kinematics and its concepts for better performance. It will give the educators a prerogative belief to improved self-confidence and motivation and enjoy their teaching and do it with passion.

Educators will also consider and indulge their learners' social foundations before, during and after lesson to determine and whether the learners have the required essential skills in the concepts of both algebra and kinematics. This will add more value to learners improved knowledge and better performance in kinematics concepts in kinematics graphs. At that point the educators will be in a situation to improve learners' performance and gain more interest in kinematics (physics) as well as in algebra (mathematics)

Additionally, the study will be more important for the creation of new curricula in the areas of algebra (mathematics) and physics (physical science) for Further Education and Training (FET).

Giannakidou, Yoftsali, & Tziora, (2013), Ebaegiun, & Stephen, (2014), and Stols, & Ono, (2016) reported that a model based on professional classroom development which educators must use in their lesson to engage and make their learners participate actively and meet learners' conceptual needs. The classroom situation takes cognisance of professional development centre and the gain in knowledge are being transferred to other lessons during educators' lesson study (Stols *et al.*, 2016). Pjanic, (2014); and Stols *et al.*, (2016) further reported that lesson study is made of about four to six educators and comprised of three processes involving lesson plan, team

observation when one of them do the teaching as well as discussion of post-lesson to improve that lesson (Iksan *et al.*, 2014; Stols *et al.*, 2016).

1.7 Method of investigation

The literature study provided an indication only of which literature will be used to guide the study with a few key references. The researcher had chosen a mixed method for this study. According to Christensen & Johnson, (2012:33), most of social scientists, when opting for mixed method, are looking at the combined approaches of doing research which are qualitative and quantitative methods.

1.8 Conclusion

This introductory chapter provide an overview and the background of this study. The aims and objectives of the study were outlined, as well as questions relating to the study. This chapter also highlighted the theoretical framework underpinning the study. In addition, the key concepts were defined. The next chapter will focus on the literature review pertinent to this study.

Chapter 2: Literature review and Theoretical Framework

2.1 Introduction

The literature study will reflect on the following points:

- The use of graphs in physics (in general and regarding laboratory work), including
 - A graph as a summarized and conclusive result of a scientific investigation in an experiment or research (Stefanel, 2019; Beeken, 2014; Deacon, 1999). A graph gives visual pattern recognition to see trends in complex data (Shishigu, Hailu, and Anibo, 2017; Beichner, 1993; Mokros & Tinker, 1987; Rojas, 2010).
 - With the aid of curve fitting some meaningful physics can be extracted from the data (Albert, and Tullis, 2013; Few, 2006). For example, the position of a free-falling object under gravity is described by a polynomial function whose coefficients represent gravitational acceleration, initial velocity, and initial position.
- The mathematical concept of a function and the graphical and algebraic representation of a function are powerful tools by which one can predict the behaviour of physical systems as conditions change (Stefanel, 2019; Beeken, 2014; Deacon, 1999).
- Problems that students may have with interpretation of graphs in physics which involves conceptual understanding: Students find it difficult to connect graphs to physical concepts as well as to connect graphs to real world situations (De Cock, 2012; McDermott, Rosenquist & Van Zee, 1987).
- Students can often not distinguish among different types of motion graphs such as velocity-time and acceleration-time graphs (De Cock, 2012; McDermott, Rosenquist & Van Zee, 1987).
- Students experience problems in finding the slope of a kinematics graph and are often unable to interpret the meaning of the area under a line graph (Phage, 2018; Beichner, 1993).
- Students' difficulties with physics may be due to the complexity of the subject and inadequacies in their skills and knowledge of mathematics (Susac, Bubic, Kazotti, Planinic, and Palmovic, 2018; Basson, 2002)

The issue of comprehension strategies of learners needs to be investigated properly as it determines the development of the ability to teach by the teachers (Sánchez-Matamoros, Fernández, and Llinares, 2015; Reutzel, Smith & Fawson, 2005, Williams, Stafford, Lauer, Hall, & Pollini, 2009). A set of comprehension strategies, on the acquisition of knowledge through reading science books together with science content knowledge retention and curriculum-based reading, were used to measure this development of the ability of the teachers to teach. Although this research will be conducted with high school physical science teachers and learners, the researcher think it still applies in the teaching of introductory undergraduate physics students.

Teaching algebraic and kinematics graph needs this set of comprehension strategies. Sánchez-Matamoros, *et. al.*, (2015) analyzed the skill of ability of preservice educators to interpret solutions of problems written by learners before and after their teacher training programs. The skill links with the progress by these educators to understand mathematics elements used by learners in problem solving links.

Another investigation, how teachers at high school can be able to use, is the context-based and science–technology–society (STS) approaches. Hérold, & Ginestié, (2018) and Bennett, Lubben, & Hogarth, (2006) stated that the use of context based, and STS approaches have dominated the teaching of science in high schools worldwide for a long time, over two decades. The basis of understanding of science and positive attitudes towards science for future studies were attributed to these approaches. Therefore, if teachers are really practicing these in the teaching of graphs in algebra and in kinematics, learners entering university studies should not struggle in using and applying this knowledge. Perhaps this is the perception or impression or even expectation of university lecturers about their first-year undergraduate students, hence their failure to comprehend why students are unable to use their prior knowledge from high school.

Cognizance must also be given to the various education policies the teachers have to undergo and implement. We have seen in the spate of new democratic era in South Africa, the education system has changed from Outcome Based Education (OBE) to the National Curriculum Statement (NCS) and up until recently in high schools Curriculum and Assessment policy Statement (CAPS) is being implemented and practiced. The study will also investigate whether teachers are able to share and

explain the learning outcome from the first day and onwards according to OBE policy of the government. The CAPS document of the National Department of Education (DoE) identifies learning outcomes and assessment standards of the learning area statements are stated to achieve the identified goals, expectations and outcomes of learning and teaching.

Teaching and learning of the curriculum-based problem solving in kinematics is important and needs to be determined in accordance with teachers' beliefs and values in this matter (Toksoy, and Çalışkan, 2015; Kuo, 2004). In this manner, metacognition must be emphasized, and teachers must see its value from the curricular materials. It is therefore the duty of teachers to ensure and value the learners' problem-solving approach metacognition and they should not focus on how they teach problem solving or their style of teaching (Zhou, Du, Hau, Luo, Feng, & Liu, 2020; Girvan, Conneely, & Tangney, 2016; Darling-Hammond, 2008; Fernandez, Hadaway, & Wilson, 1994).

For efficient and effective teaching of graphs in algebra and kinematics, the inclusion of data handling as proposed in the Further Education and Training (FET) mathematics curriculum (DoE, 2003:4) is very important. As stated previously, the researcher will investigate whether the mathematics teachers have the capacity and ability to teach mathematics and hence students can carry that skill, knowledge and understanding to apply and use in it in other study field areas including kinematics in physics. Low level out of mathematics has led to the incapacity to produce qualified mathematics teachers (DoE 2001:13) and as results under-qualified physical science teachers also. This is in explanation or relation to what might be the cause of inability to teach physics or unqualified physical science teachers.

According to the low level of output, particularly in Mathematics, has a direct impact on the capacity of the system to produce qualified teachers in Mathematics. Phillip, (2021) and Rotbain, Y., Marbach-Ad, & Stavy, (2008), found out that teachers confirmed that simulation as another teaching strategies helped them effectively teach the abstract concepts like kinematics and as a result, they were able to gain insight into students' learning process. Questions have been asked about nudging learners (children and adolescents) as well as parents in making better decisions about education and if educators can be nudged to support and influence the decision making (Damgaard & Nielsen, 2018). They reiterated that nudging has two effects,

positive and negative. One effect is the invention measures for individual learners that affected and target their learning (behaviour) barrier. The other effect is intrinsic motivation like pressure on individual learners and insufficient understanding of mechanisms of behaviour like the subject choices (mathematics and physical science) and lack of interest in them. According to Olivier, Galand, Hospel, & Dellisse, (2020) and Clarke (2005), low-performing schools' performance is likely to fluctuate both up and down over a short period of time, and he refers to this as "natural variation." This is due to various factors influenced by behavioural mechanisms.

This is confirmed by Desimone, Smith & Phillips, (2013) that educators' focus should be more unconventional mathematics topics such operations, statistics, etc., and put more emphasis on problem-solving skills. This will lead to a quick growth in and enhance learners' performance unlike teaching basic topics which encourages memorising and a drop in learners' understanding and performance. Desimone, et.al, (2013) further discovered that professional teacher development assists in ensuring educators are flexible using various and effective instructional approaches in the mathematics content and associate their teaching to the growth of learners' understanding and growth in their performance.

2.2 Theoretical framework

It is firstly important to understand the meaning of science, which encompass physics as on its subject. Kinematics and graphing are a topic within the physics subject. Nwosu, 2019 and Bosman (2006) emphasised that science is more about content knowledge of subject matter and therefore it is imperative teachers to teach learners effectively, they should be fully equipped to deliver on the nature of science, its philosophies and how it relates to culture. She further stated that for learners to develop scientific literacy, teachers must possess process skills in addition to the values and attitudes necessary for science to complement their subject matter expertise. She reported that a very small percentage of science teachers perceived them as not scientifically literate as result they are unable to scientific literacy among their learners. The view by engineers and physicists, that the thinking and solving problems is a set of tools in science (Nwosu, 2019; Bosman, 2009).

Studies have simulation such as a David Trowbridge model of Microsoft Graphs and Tracks instead of data collection to depict that an object moving along an incline possesses position, velocity and acceleration which can be summarised in a graph. (Sokoloff, Thornton, and Laws, 2011; Canham, and Hegarty, 2010; Laws, 1991). The comprehension of line graphs is reported to be from an integrated series of different types such as recognition of patterns that interpret and give qualitative and quantitative information as meant by labels and titles (Canham, & Hegarty, 2010). Micro-Computer Based Laboratory as a kinematics tool has been reported to be an effective tool for students when collecting data and displaying kinematics graphs in real time (Laws, 1991, Canham, and Hegarty, 2010 and Sokoloff, Thornton, & Laws, 2011). The problem with this tool is that it does not enhance students' ability to generate graphs as opposed to using robotics to enhance their ability to draw and understand kinematics graphs. (Cen, Ruta, Powell, Hirsch, and Ng, 2016; Mitnik, Recabarren, Nussbaum and Soto, 2009). In this manner conceptual understanding of kinematics was reinforced.

Cen, *et.al.*, (2016) and Mitnik, *et. al.*, (2009) reported that being able to draw and interpret graph is an important skill to understand science and lack of it can be seen as a limiting factor and handicap for conceptual understanding of science. Students of all ages cannot use the prior learning of graphs in algebra to associate them with kinematics concepts like position, velocity, and acceleration (Mitnik, et al., 2009).

Students perceive that interpersonal communication by their educators being approachable as a prerequisite for their effective learning (Hermida, 2014; Delaney, Johnson, Johnson and Treslan, 2010). They further reported that there is a need to investigate effective teaching perceptions by both students and institution (s), the change in students' beliefs of effective physics teaching using mathematics, as well as comparisons of their perceptions on effective teaching.

It has been investigated that some teachers perceive the teaching of physics concepts as easy even though their students find those concepts difficult to learn (Gumede, 2020; Rankhumise & Raphoto, 2014; Gunstone, Mulhall, & McKittrick, 2009). They reported that the well informed and skilled teachers in the physics concepts are the ones who understand and have sentiments with the teaching difficulties of such concepts.

There is a connection between conceptual understanding of mathematics and physics due roles played in physics formulas by mathematics, but students see formulas as operation, and they are unable to translate them. The derivation of physics principles and the modelling of good strategies to solve physics problems using mathematically in the classroom gave less effect as students failed to notice the advantage of doing so (Rajapaksha, and Hirsch, 2017; Kortemeyer, 2007). Kortemeyer (2007) suggested the use of translation and symbolic problems than to use textbook-based problems.

Bollen, et. al, (2016) discovered that students in algebra-based physics tend to make more mistake than calculus-based students. However, they both have common problems when dealing with division of coordinates. They further stated that students' prior knowledge in mathematics and physics, as well as questions corresponding or similar in form and relations, lead to the common existence of their approaches and pass rates.

The tendency of educators or instructors to teach as if the learners are experts in the concept shows a disconnection between physics teachers and their students (Rajapaksha, and Hirsch, 2017; Kortemeyer, 2007). He said this is because students find physics foreign and unintuitive and as a result, they are only interested in memorising its formulas and to plug in the values in solving physics problems and they want to pass the subject without any sound conceptual understanding or application. It will therefore be important for educators to use assessment strategy that is deals with conceptual solutions and solving problems.

2.3 Pedagogical Content Knowledge (PCK) in Science Education

Various researchers (Hoffman, 2015; Mudaly and Moore-Russo, 2011, Rowland, Huckstep & Thwaites, 2005) stated that teacher's knowledge according to Shulman's (1986) categories as subject matter knowledge (SMK) or content knowledge (CK), pedagogical content knowledge (PCK), and curricular knowledge (CK). Kalobo (2014, p. 96), citing Shulman (1986), defines "the pedagogic content knowledge as an integral form of content knowledge". Ball, Thames, and Phelps, (2008) stated that content knowledge is a relatively unexplored aspect in teaching and lacks the knowledge of pedagogy, students, curricula, and some other non-content areas. Du Toit (2012) define curriculum knowledge as the knowledge developed as means of sustaining a

specific module/subject teaching from a variety of subjects or module in the programme.

PCK is regarded as tool that involves the specialist knowledge of teaching such as practice, expertise, meaning, better understanding and high value of the actual teaching (Loughran, Berry & Mulhall, 2012). It can be referred to as the art by which science topics can be conceptualised and transferred to students in the classroom by the teacher. PCK, including content knowledge (CK), is a test of the competence and effectiveness of the teachers as to their teaching style or strategy, and how what they decide in the classroom influence their teaching and the progress made by their students (Mudaly & Moore-Russo, 2011, Hubber, Tytler, Haslam, 2010, and Vistro-Yu, 2000).

Kleickmann, Richter, Kunter, Elsner, Besser, Krauss, and Baumert, (2013) reported that Pedagogical content knowledge (PCK) and content knowledge (CK) are key factors proving that competence of the teachers determines progression of students. Maries and Sigh, (2013) discovered that teachers identified students' difficulties are context based and teachers' discussions helped to improve students understanding of these difficulties.

Understanding and development of pedagogical knowledge is also important in teacher preparedness for the classroom. Nilsson and Loughran (2012) reported that there are possible ways of improving teachers' continuous professional development in teacher preparation, in terms of their science teaching strategies, and this will make teachers understand and develop better the nature of PCK. As a result, it is an imperative, unavoidable, and challenging task to develop competence of teachers in restructuring the PCK and beliefs (Nilsson, 2014).

It is therefore important to cultivate the nature and progression of science teacher learning and find ways to them (Schneider and Plasman, 2014). They investigated the ways in which the knowledge of science teachers can be developed and their sequence. They concluded that before teaching, teachers should first think of the students and that through the reflection of their teaching, ways of developing their PCK can be rearranged. Professional development programs in support of science teachers learning will therefore be designed.

From the above discussions it can be mentioned that kinematics and algebraic graphs, as part of physics and mathematics modules or subjects, are content knowledge (CK) and have pedagogical knowledge. The perceptions of high school physical science teachers in the teaching of kinematics and algebraic graphs will help to develop PCK programmes towards teacher preparedness and its understanding.

2.4 Literature review on the use of graphs in physics

Research has been done where teachers believe that they possess and they display expertise in didactical skills but not pedagogical skills since social and emotional matters not part of the subject content (Vähäsantanen, 2015; Beijaard, Verloop, Vermunt, 2000, Akkerman, and Meijer, 2011). They reported that teachers who perceive themselves as subject matter and pedagogical experts refer to teaching as more of knowledge transmission. They concluded that from the moral and ethical perspective of teaching profession, didactics and pedagogy must be related.

A good teacher previously was regarded as someone with subject matter/content knowledge and is hands on, i.e., has on the job training (Hoyle & John, 1995, Sheldon, Fesenmaier, and Tribe, 2011; Fernandes, Vieira, Rodrigues, Oliveira, and Mota, 2017). Now due to teaching complexities, teaching is regarded to incorporate conceptual knowledge including managing the classroom, facilitating learning, etc (Fernandes, *et. al.*, 2017; Hoyle & John, 1995, Sheldon, *et. al.*, 2011). A full and deep content knowledge and understanding of subject matter coupled with a lot of conceptual knowledge and their relationships is also a requirement of a teacher (Calderhead, 1996, Bhargava, and Pathy, 2011).

Planinic, Milin-Sipus, Katic, Susac, and Ivanjek, 2012 did an investigation into difficulties between questions including graphs on kinematics and their related algebra questions. Teachers were of the perception that students will perform poorly in algebra questions than kinematics. Quite contrary to this, students perform well in algebraic questions than kinematics questions, meaning students do have mathematical skills and this is not a cause for their difficulties in solving kinematics equations and graphs (Planinic, Milin-Sipus, Katic, Susac, and Ivanjek, 2012, Phage, 2015). Learners are confused as to the meaning of gradient of a kinematics graph. They also show confusion in the Slope /height of a graph in both kinematics and algebra (Friel, *et. al.*,

2001, Planinic, et. al., 2012, Phage, 2015). Both researchers further proved that contrary to the educators' beliefs that learners will perform poorly in algebraic questions than in kinematics problems. This meant that problem is in the learners' inability to relate and associate the algebraic graphs and functions (mathematics) with those in kinematics graphs and equations.

Djan (2014) reported that students need basic graph (algebraic) conceptual knowledge and skills to apply them in solving problems in kinematics graphs and this leads to poor performance or poor results in physical science from high school. Kalobo (2014) believes that to enhance the effective use and interpretation of these basic graph skills accordingly, statistics should be taught in schools. He reported that data collection learnt in Statistics could therefore be represented and summarised in the form of charts and or graphs and interpret that graph/s in the end. Teachers should therefore be able to introduce and explain graphs to learners using resources from the learners' prior knowledge of drawing a table of data collected (Kalobo, 2014). In this manner the students will develop and formulate conceptual skills required to plot, analyse, and interpret a graph or to interpret/analyse a given graph (Kalobo, 2014; Phage, 2015). Graphing understanding and knowledge are vital and significant as Kalobo (2014) also stated: "Learners' understanding of graphs and functions can both enhance and be enhanced by addressing problems that involve data analysis and Statistics in authentic situations". Furthermore, the representation on the Cartesian plane allows one to link the properties of a function to those of a graph of that function." (Bautista, 2015:91)

Curriculum and Assessment Policy Statement (DBE, 2011) also emphasizes clearly that learners should be able to communicate using graphs also, i.e., use graph as a means of communication. Teachers should therefore be able assess procedural knowledge of learners based on reading and construction of graphs ability of the learners (Kalobo, 2014 citing Dossey, Giardano, McCrone & Weir, 2002). Szyjka (2012) reported on the theory by Jean Piaget's (1964a), and Piaget, Garcia, and Davidson, 2013) of cognitive development (TCD) in logical thinking that is required for cognitive developments. He emphasized that this theory is required to overcome both mathematics education and science education learning and underpins it. Development of knowledge is action based and operational according to Piaget in terms of cognitive

skills and manipulation of prior knowledge which build thinking transformation and conceptual understanding (Szyjka, 2012).

According to Piaget schemas, borne in the mind and critical in the learning process and used in knowledge construction, assist students in the interpretation of information (Szyjka, 2012). Graphing skill, consisting of components of graph, e.g., slope, y-intercept, etc., has been given a relatively less attention (Phage, *et. al.*, 2017, Hattikudur, Prather, Asquith, Alibali, Knuth, & Nathan, 2012). Line graphing performance in science, physics in this instance, made up out of the mathematical skills according to Szyjka (2012) therefore highly depends on this reasoning. Szyjka (2012) continues to explain that conceptual understanding and procedures, data and statistical analysis and problem solving are the skills in applied mathematics (Illinois State Board of Education [ISBE], 2009, Sriraman, and English, 2009) as well as visual perception (Hattikudur, *et. al.*, 2012; Friel, Curcio, & Bright, 2001, González, Espinel, and Ainley, 2011) needed in this regard.

For improvement of the understand graphs in kinematics, Djan (2014) stated that a progressive integration of mathematics and physics from Grade 9 is required where straight line graphs should be given more emphasis in Grade 9 so that learners gain concept understanding of the basics of kinematics graphs in Grade 10. Cognitive factors used in science education also led to the integration of scientific thing and reasoning in graphs into mathematics teaching methodologies for in-service and or elementary pre- service educators (Szyjka, 2012). Teaching, therefore, of physics/science and mathematics required a more oriented approach an inquiry-based strategies. Integrating scientific type thinking and graphical reasoning into mathematics methods teaching mathematical achievement of the elementary pre-service teachers sampled in this study was influenced, in part, by cognitive factors typically emphasized in science education (Rowland, Huckstep, & Thwaites, 2005, Rowland, Turner, and Thwaites, 2014).

Previous studies have reported that student do not have a problem to plot a graph of a given function and to read-off function values from a given graph, but their problem is their inability in the construction and interpretation of kinematics meaningfully (Phage, 2015, Djan, 2014, Lavery, and Kortemeyer, 2012). Their failure is in the interpretation of graphs as functions and in the physical world. For students to be able

in graphs, it is advisable work with graphs in the classroom (Lavery, and Kortemeyer, 2012).

The issue of comprehension strategies of learners needs to be investigated properly as it determines the development of the ability to teach by the teachers (Oczkus, 2018; Reutzel, Smith and Fawson, 2005, Williams, Stafford, Lauer, Hall, and Pollini, 2009). A set of comprehension strategies, on the acquisition of knowledge through reading science books together with science content knowledge retention and curriculum-based reading, were used to measure this development of the ability of the teachers to teach. Although this research will be conducted with high school physical science teachers and learners, the researcher think it still applies in the teaching of introductory undergraduate physics students. Teaching algebraic and kinematics graph needs this set of comprehension strategies.

Another investigation, how teachers at high school can use, is the context-based and science–technology–society (STS) approaches. Hérold, & Ginestié, J., (2018) and Bennett, Lubben, Hogarth, (2007) stated that the use of context based, and STS approaches have dominated the teaching of science in high schools worldwide for a long time, over two decades. The basis of understanding of science and positive attitudes towards science for future studies were attributed to these approaches. Therefore, if teachers are really practicing these in the teaching of graphs in algebra and in kinematics, learners entering university studies should not struggle in using and applying this knowledge. Perhaps this is the perception or impression or even expectation of university lecturers about their first-year undergraduate students, hence their failure to comprehend why students are unable to use their prior knowledge from high school.

Cognizance must also be given to the various education policies the teachers have to undergo and implement. We have seen in the spate of new democratic era in South Africa, the education system has changed from Outcome Based Education (OBE) to the National Curriculum Statement (NCS) and up until recently in high schools Curriculum and Assessment policy Statement (CAPS) is being implemented and practiced. The study will also investigate whether teachers are able to share and explain the learning outcome from the first day and onwards according to OBE policy of the government. The CAPS document of the National Department of Education (DoE) identifies learning outcomes and assessment standards of the learning area

statements are stated to achieve the identified goals, expectations and outcomes of learning and teaching.

Teaching and learning of the curriculum-based problem solving in kinematics is important and needs to be determined in accordance with teachers' beliefs and values in this matter (Toksoy, Çalışkan, 2015; Kuo, 2004). In this manner, metacognition must be emphasized, and teachers must see its value from the curricular materials. It is therefore the duty of teachers to ensure and value the learners' problem-solving approach metacognition and they should not focus on how they teach problem solving or their style of teaching (Fernandez, et. al., 1994, Darling-Hammond, 2008; Girvan, et. al., 2016).

For efficient and effective teaching of graphs in algebra and kinematics, the inclusion of data handling as proposed in the Further Education and Training (FET) mathematics curriculum (DoE, 2003) is very important. As stated previously, the researcher will investigate whether the mathematics teachers have the capacity and ability to teach mathematics and hence students can carry that skill, knowledge and understanding to apply and use in it in other study field areas including kinematics in physics. Low level out of mathematics has led to the incapacity to produce qualified mathematics teachers (DoE 2001) and as results under-qualified physical science teachers also. This is in explanation or relation to what might be the cause of inability to teach physics or unqualified physical science teachers.

According to the low level of output, particularly in Mathematics, has a direct impact on the capacity of the system to produce qualified teachers in Mathematics. Phillip, (2021) and Rotbain, et. al., (2008), found out that teachers confirmed that simulation as another teaching strategies helped them effectively teach the abstract concepts like kinematics and as a result, they were able to gain insight into students' learning process.

Bing and Reddish (2007) investigated that "An important sign of physics students' progress is their combining the symbols and structures of mathematics with their physical knowledge and intuition, enhancing both. The numbers, variables, and equations of the mathematics come to represent physical ideas and relations." Therefore, it is important to investigate their previous knowledge in Mathematics and/or Physics and if not, learning from the high school teachers' perspectives.

Various researchers, Phage, et al, 2017; Hu & Rebello, 2013; Basson, 2002, etc., have reported that there are difficulties with students to transfer their knowledge of mathematics to physics. As a result, Hu & Rebello, (2013) and Bing & Reddish (2007) discovered that students were unable to blend both their knowledge productively in algebra (mathematics) and kinematics (physics) even though they possess prior learning knowledge of mathematics.

2.5 Importance of subject matter knowledge in teaching

Murray and MacDonald (1997) have reported from aspects of qualitative analysis on some of the interesting conceptual variations in terms of the role of an educator, purpose of a lesson, and class tutorial tasks. They discovered some inconsistencies in these conceptions and explored them. Learners or students see the main teaching conception of the educator as that of knowledge imparting, learner support provision, stimulating, and encouraging their learners, learning environment facilitation and or some of these combined conceptions (Murray and MacDonald, 1997).

They found out that most educators regarded their roles as facilitating the learning environment and or supporting their learners. They further discovered that there was a conflict between what the role of the teacher is as compared to common and constant utilization of lessons and class tasks to impart, apply and or check or test imparted knowledge and understanding. These led to a disjunction commonly known as mysteries of higher learning in terms of what is aimed to be taught and the actual practice of teaching. The attitudes and opinions or principles portrayed by educators do not actually translate into their strategies and methodologies of teaching.

From previous research (Phage, 2015) it has been observed that it appeared most introductory undergraduate physics students at a University of Technology (UoT), from interaction with the researcher, have been found not to be able use or to link to these linear algebraic knowledge and skills in solving kinematics problems and in presentation of their kinematics experimental laboratory reports. They tend to lack recognition prior learning of their high school content knowledge in physics as well as the use mathematics skills and knowledge. These students perform poorly in physics and hence a high failure rate and drop out in physics at introductory, though introductory physics is just an introductory part using and applying more of their high school knowledge. The probe of these students' deficiencies might give an indication

that there could be remedial action through the assistance or involvement of their high school teachers, which could help in alleviating these problems.

The current state of teaching and learning in kinematics and linear algebraic graphs in the physical science and mathematics FET curricula in the Motheo district will be investigated, explained, and described into perspective in this research. The study will be conducted in this manner to design questionnaire and interview questions. Therefore, a non-experimental design as a data-collection design in this study will help to do this. From among the six types of non-experimental designs (McMillan & Schumacher, 2006), The researcher will therefore be able to use a description of the learners' participation during graph in kinematics and algebra activities, the teachers' involving learners during graph in kinematics and algebra activities, the teachers' views and perceptions of the learners' literacy in graphs, and the teachers' professional development in the teaching of graphs. For The non-experimental research design used by the researcher will describe events that will occur or might have occurred and even look at how to relate experienced events without manipulating their conditions directly (McMillan and Schumacher, 2006).

The literature review will provide the conceptual framework necessary for this study. It will also be used to design the grade 10 - 12 teachers' questionnaires, and teachers' interview. The questionnaire covered topics relating to kinematics graphs and equations (physics) and linear functions and graphs (algebra). to probe the teachers' perceptions on their learners' understanding of these concepts. The research will also do document analysis in addition to questionnaires and interviews. The interviews will mainly be for the sole purpose of getting the teachers' reasoning in terms of their choice or answers from the questionnaire. Furthermore, from interviews, researcher will find out if these teachers think their learners are able to integrate kinematics and algebraic knowledge and understanding. With the document analysis, the researcher will investigate what the policies say in terms of the teachers' guide in teaching these concepts as well as investigate the learning outcome and teaching objectives in these fields.

This non-experimental research design is a survey that uses the knowledge, attitudes, or behaviours of the reports of individuals (Mertens, 2010). Qualitative research as a fundamental objective will assist to create a reconstruction the individuals' (teachers) perspectives and meanings. This will help researchers to acknowledge their own

subjective contribution to the process and therefore act within the framework of constructivism (Springer, 2010).

2.6 The use of graphs in kinematics concept from physics

It is imperative in to better inform the performance of teaching and to distinguish the rationale between teaching expertise and experienced teaching are all about. This is well to define the rationale behind a teaching prototype (Jacobsen, M. (2018). This has also an implication on the teaching and or learning of graphs in kinematics and algebra and what principles inform the teaching of kinematics graphs from the knowledge and understating of algebraic graphs.

Jacobsen, M. (2018: 72) mentioned that Sternberg & Horvath (1995) identified the three ways expert teachers are different from their novices' counterparts. The expert teachers: "(1) bring knowledge to bear more effectively on problems than do novices, (2) solve problems more efficiently and do more in less time, than do novices, and (3) are more likely to arrive at novel and appropriate solutions to problems than are novices. Knowledge, efficiency, and insight are the primary features upon which the expert teacher prototype is founded".

The researcher would therefore try to relate how these how effective or effectively do these characteristics and their impact in the classroom apply in terms in relation to high school physical science teachers (experts vs novices).

Previous studies (Seyhan, 2014) on teachers were conducted to obtain their perceptions of and determine:

- their problem-solving applications performances,
- the levels of their perception for problem-solving skills and,
- if their problem-solving applications and their performances may be used to predict as their perception of certain variables in terms of skills required for problem-solving and scientific process.

It is firstly important to understand the meaning science, which encompass physics as on its subject. Kinematics and graphing are a topic within the physics subject or concept. Bosman (2006) emphasised that science is more about content knowledge

of subject matter and therefore it is imperative teachers to teach learners effectively, they should be fully equipped to deliver on the nature of science, its philosophies and how it relates to culture. She further stated that for learners to attain scientific literacy, educators should possess the procedural skills, values, and attitudes necessary for science in addition to their subject-matter expertise. She reported that a very small percentage of science teachers perceived them as not scientifically literate as result they are unable to instil scientific literacy among their learners. The view by engineers and physicists, that the thinking and solving problems is a set of tools in science (Bosman, 2009).

Studies have simulation such as a David Trowbridge model of Microsoft Graphs and Tracks instead of data collection to depict that an object moving along an incline possesses position, velocity and acceleration which can be summarised in a graph (Ibrahim, & Rebello, 2013). (Laws, 1991, Sokoloff, Thornton, and Laws, 2011, Canham, and Hegarty, 2010). The comprehension of line graphs is reported to be from an integrated series of different types such as recognition of patterns that interpret and give qualitative and quantitative information as meant by labels and titles (Canham, and Hegarty, 2010). Micro-Computer Based Laboratory as a kinematics tool has been reported to be an effective tool for students when collecting data and displaying kinematics graphs in real time (Laws, 1991, Canham, and Hegarty, 2010 and Sokoloff, Thornton, and Laws, 2011). The problem with this tool is that it does not enhance students' ability to generate graphs as opposed to using robotics to enhance their ability to draw and understand kinematics graphs. (Mitnik, Recabarren, Nussbaum and Soto, 2009). In this manner conceptual understanding of kinematics was reinforced.

Mitnik, Recabarren, Nussbaum and Soto (2009) reported that being able to draw and interpret graph is an important skill to understand science and lack of it can be seen as a limiting factor and handicap for conceptual understanding of science. Students of all ages cannot use the prior learning of graphs in algebra to associate them with kinematics concepts like position, velocity, and acceleration.

Students perceive that interpersonal communication by their educators being approachable as a prerequisite for their effective learning (Delaney, Johnson, Johnson and Treslan, 2010). They further reported that there is a need to investigate effective teaching perceptions by both students and institution (s), the change in students'

beliefs of effective physics teaching using mathematics, as well as comparisons of their perceptions on effective teaching.

It has been investigated that some teachers perceive the teaching of physics concepts as easy even though their students find those concepts difficult to learn (Gunstone, Mulhall, McKittrick, 2009). They reported that the well informed and skilled teachers in the physics concepts are the ones who understand and have sentiments with the teaching difficulties of such concepts.

There is a connection between conceptual understanding of mathematics and physics due roles played in physics formulas by mathematics, but students see formulas as operation, and they are unable to translate them. The derivation of physics principles and the modelling of good strategies to solve physics problems using mathematically in the classroom gave less effect as students failed to notice the advantage of doing so (Kortemeyer, 2007). Kortemeyer (2007) suggested the use of translation and symbolic problems than to use textbook-based problems.

The tendency of educators or instructors to teach as if the learners are experts in the concept shows a disconnection between physics teachers and their students (Kortemeyer, 2007). He said this is because students find physics foreign and unintuitive and as a result, they are only interested in memorising its formulas and to plug in the values in solving physics problems and they want to pass the subject without any sound conceptual understanding or application. It will therefore be important for educators to use assessment strategy that is deals with conceptual solutions and solving problems.

2.7 Conceptual Framework

2.7.1 Aspects of kinematics and graphs theories

Research has been done where teachers believe that they possess, and they display expertise in didactical skills but not pedagogical skills since social and emotional matters not part of the subject content (Beijaard, Verloop, & Vermunt, 2000, Akkerman, & Meijer, 2011). They reported that teachers who perceive themselves as subject matter and pedagogical experts refer to teaching as more of knowledge

transmission. They concluded that from the moral and ethical perspective of teaching profession, didactics and pedagogy must be related.

A good teacher previously was regarded as someone with subject matter/content knowledge and is hands on, i.e., has on the job training (Hoyle & John, 1995, Sheldon, Fesenmaier, & Tribe, 2011). Now due to teaching complexities, teaching is regarded to incorporate conceptual knowledge including managing the classroom, facilitating learning, etc (Hoyle & John, 1995, Sheldon, Fesenmaier, and Tribe, 2011). A full and deep content knowledge and understanding of subject matter coupled with a lot of conceptual knowledge and their relationships is also a requirement of a teacher (Calderhead, 1996, Bhargava, and Pathy, 2011).

2.7.2 Graphs in algebra and graphs in Kinematics

Planinic, Milin-Sipus, Katic, Susac, and Ivanjek, 2012 did an investigation into difficulties between questions including graphs on kinematics and their related algebra questions. Teachers were of the perception that students will perform poorly in algebra questions than kinematics. Quite contrary to this, students perform well in algebraic questions than kinematics questions, meaning students do have mathematical skills and this is not a cause for their difficulties in solving kinematics equations and graphs (Planinic, Milin-Sipus, Katic, Susac, and Ivanjek, 2012, Phage, 2015). They are confused as to the meaning of gradient of a kinematics graph. They also show of confusion in the Slope /height of a graph in both kinematics and algebra (Friel, Curcio, and Bright, 2001, Planinic, Milin-Sipus, Katic, Susac, and Ivanjek, 2012, Phage, 2015).

Djan (2014) reported that students need basic graph (algebraic) conceptual knowledge and skills to apply them in solving problems in kinematics graphs and this leads to poor performance or poor results in physical science from high school. Kalobo (2014) believes that to enhance the effective use and interpretation of these basic graph skills accordingly, statistics should be taught in schools. He reported that data collection learnt in Statistics could therefore be represented and summarised in the form of charts and or graphs and interpret that graph/s in the end. Teachers should therefore be able to introduce and explain graphs to learners using resources from the learners' prior knowledge of drawing a table of data collected (Kalobo, 2014). In this manner the students will develop and formulate conceptual skills required to plot, analyse, and interpret a graph or to interpret/analyse a given graph (Kalobo, 2014,

Phage, 2015). Graphing understanding and knowledge are vital and significant as Kalobo (2014: 85) also stated: “Learners’ understanding of graphs and functions can both enhance and be enhanced by addressing problems that involve data analysis and Statistics in authentic situations. Furthermore, the representation on the Cartesian plane allows one to link the properties of a function to those of a graph of that function. “Curriculum and Assessment Policy Statement (DoE, 2011) also emphasizes clearly that learners should be able to communicate using graphs also, i.e., use graph as a means of communication. Teachers should therefore be able assess procedural knowledge of learners based on reading and construction of graphs ability of the learners (Kalobo, 2014 citing Dossey, Giardano, McCrone & Weir, 2002).

Szyjka (2012) reported on the theory by Jean Piaget’s (1964a) (Piaget, Garcia, and Davidson, 2013) of cognitive development (TCD) in logical thinking that is required for cognitive developments. He emphasized that this theory is required to overcome both mathematics education and science education learning and underpins it. Development of knowledge is action based and operational according to Piaget in terms of cognitive skills and manipulation of prior knowledge which build thinking transformation and conceptual understanding (Szyjka, 2012).

According to Piaget schemas, borne in the mind and critical in the learning process and used in knowledge construction, assist students in the interpretation of information (Szyjka, 2012). Line graphing performance in science, physics in this instance, made up out of the mathematical skills according to Szyjka (2012) therefore highly depends on this reasoning. Szyjka (2012) continues to explain that conceptual understanding and procedures, data and statistical analysis and problem solving are the skills in applied mathematics (Illinois State Board of Education [ISBE], 2009, Sriraman, and English, 2009) as well as visual perception (Friel, Curcio, & Bright, 2001, González, Espinel, and Ainley, 2011) needed in this regard.

2.7.3 The relationship between graphs in algebra and graph in kinematics

Studies has been done to identify that not enough research has been done in South Africa on how students conceptualize and experience physics, kinematics in this case, with reference to the algebraic sign usage in vector analysis of kinematics (Eriksson, 2014). In his study, he discovered that five different qualitative categories that could be varied to characterise the way students use signs in algebra. He concludes that

undergraduate physics pre-service teachers need to be trained with a deeper and wider understanding of the difficulties learners have. In so doing, they will be well prepared to teach, align their teaching with, and meet the challenges arising from such learners' difficulties. It is therefore on this notion that this study will find the perceptions and ability of high school physical science teachers to relate and match algebraic concepts and variables with those in kinematics.

For improvement of the understand graphs in kinematics, Djan (2014) stated that a progressive integration of mathematics and physics from Grade 9 is required where straight line graphs should be given more emphasis in Grade 9 so that learners gain concept understanding of the basics of kinematics graphs in Grade 10. Cognitive factors used in science education also led to the integration of scientific thing and reasoning in graphs into mathematics teaching methodologies for in-service and or elementary pre- service educators (Szyjka, 2012). Teaching, therefore, of physics/science and mathematics required a more oriented approach and an inquiry-based strategies.

Integrating scientific type thinking and graphical reasoning into mathematics methods teaching mathematical achievement of the elementary pre-service teachers sampled in this study was influenced, in part, by cognitive factors typically emphasized in science education (Rowland, Huckstep, & Thwaites, 2005, Rowland, Turner, and Thwaites, 2014). Previous studies have reported that student do not have a problem to plot a graph of a given function and to read-off function values from a given graph, but their problem is their inability in the construction and interpretation of kinematics meaningfully (Phage, 2015, Djan, 2014, Lavery, and Kortemeyer, 2012).

2.8 Nature of graphs and its relation to science teaching

Further studies (American Association for the Advancement of Science (AAAS), 1993, Next Generation Science Standards (National Research Council (NRC), 2013 and Phage, 2015) have reiterated that knowledge of graphs is also required for students to be able to do mathematics and computational thinking, analysis, and interpretation of data, provide evidence for their arguments and communicate even on completion of their high school years. Their failure is in the interpretation of graphs as functions

and in the physical world. For students to be able in graphs, it is advisable work with graphs in the classroom (Lavery, and Kortemeyer, 2012).

Emine, (2015) stated that instructors for pre-service science training must take cognizance of the difficulties their students are having in the comprehension of kinematic graphs. To do that, they must enforce or stimulate skills of graph interpretation on the pre-service teachers for them to have a better understanding of graphs and to be able to instil to their learners in the teaching and learning of algebra and kinematics (Jacobbe and Horton, 2010). This will reduce if not eliminate the weak pre-knowledge and lack of confidence of teachers, during their schooling and training, about the concepts in kinematic context (Emine, 2015) of preservice physics teachers before they go into teaching field.

2.9 Use of graphs in physics

Bing and Reddish (2007) investigated that “An important sign of physics students’ progress is their combining the symbols and structures of mathematics with their physical knowledge and intuition, enhancing both. The numbers, variables, and equations of the mathematics come to represent physical ideas and relations.” Therefore, it is important to investigate their previous knowledge in Mathematics and/or Physics and if not, learning from the high school teachers’ perspectives.

The study is a result of the fact that the researcher observed that it appears most introductory undergraduate physics students at CUT, from interaction with them, have been found not to be able use or to link to these linear algebraic knowledge and skills in solving kinematics problems and in presentation of their kinematics experimental laboratory reports. They tend to lack recognition prior learning of their high school content knowledge in physics as well as the use mathematics skills and knowledge. These students perform poorly in physics and hence a high failure rate and drop out in physics at introductory, though introductory physics is just an introductory part using and applying more of their high school knowledge. The probe of these students’ deficiencies might give an indication that there could be remedial action through the assistance or involvement of their high school teachers, which could help in alleviating these problems.

The current state of teaching and learning in kinematics and linear algebraic graphs in the physical science and mathematics FET curricula in the Motheo district will be investigated, explained, and described into perspective in this research. The study will be conducted in this manner to design questionnaire and interview questions. Therefore, a non-experimental design as a data-collection design in this study will help to do this. From among the six types of non-experimental designs (McMillan & Schumacher, 2006:24), The researcher will therefore be able to use a description of the learners' participation during graph in kinematics and algebra activities, the teachers' involving learners during graph in kinematics and algebra activities, the teachers' views, and perceptions of the learners' literacy in graphs, and the teachers' professional development in the teaching of graphs. For The non-experimental research design used by the researcher will describe events that will occur or might have occurred and even look at how to relate experienced events without manipulating their conditions directly (McMillan and Schumacher, 2006:24).

The literature review will provide the conceptual framework necessary for this study. It will also be used to design the grade 10 - 12 teachers' questionnaires, and teachers' interview. The questionnaire is composed of related topics from linear functions and graphs (algebra) and kinematics graphs and equations (physics) to probe the teachers' perceptions on their learners' understanding of these concepts. The research will also do document analysis in addition to questionnaires and interviews. The interviews will mainly be for the sole purpose of getting the teachers' reasoning in terms of their choice or answers from the questionnaire. Furthermore, from interviews, researchers will find out if these teachers think their learners are able to integrate kinematics and algebraic knowledge and understanding. With the document analysis, the researcher will investigate what the policies say in terms of the teachers' guide in teaching these concepts as well as investigate the learning outcome and teaching objectives in these fields.

This non-experimental research design is a survey that uses the knowledge, attitudes, or behaviours of the reports of individuals (Mertens, 2010:294). Qualitative research as a fundamental objective will assist to create a reconstruction the individuals' (teachers) perspectives and meanings. This will help researchers to acknowledge their own subjective contribution to the process and therefore act within the framework of constructivism (Springer, 2010:20).

2.10 A Study of Pre-Service Science Teacher's Graphing Skills

Test items include different graph types as line graphs, bar graphs, histograms, and pie charts. Moreover, to elicit how the pre-service teachers, think while reading graphs and how they approach the questions relating to graph reading, the participants were asked to write the data they had read from the graph while responding to each test item and explain the stages of operations in their responses. Some sample items used in the study are presented in Figure 1. The pre- and post-percentages were calculated for the responses given to multiple-choice test items. In addition, one-way ANOVA was carried out to determine whether there are significant differences based on grade level among the test mean scores of the preservice teachers. On the second stage, descriptive analysis of the pre- -ended questions was carried out and, in this way, the graph types in which the pre-service teachers have greater success in reading and interpreting and the difficulties they often encounter while reading graphs were determined.

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2.11 On in-service Mathematics teachers' content knowledge on kinematics

Information regarding the second (and third, if applicable) content subject that they were currently teaching in school (besides Mathematics) was also collected.

The breakdown of the teacher's second and third teaching subjects is tabulated in Table 1 below. It was found that all the participating teachers only taught two subjects in their schools, hence no third subject is recorded below.

Mathematics Only	Computer Application s	English Language	Lower Secondary Science
22	4	3	1

Table 1: Breakdown of the Second teaching subject of the participating teachers

2.12 Conclusion

This chapter provided a review of the literature consulted regarding the teaching and learning of and functions kinematics graphs and functions in Physical Science and algebraic graphs and equations in Mathematics. The role and implications from previous studies, by the understanding and skills acquired in algebra graphs and equations to address, draw, interpret and solve kinematics graphs and equations were also investigated.

The focus was on the importance of the perceptions of the teachers and learners in relation to teaching and learning of kinematics graphs and functions using the knowledge and skills acquired from algebraic graphs and equations. It stands to reason those teachers who do not know the subject well and who do not dispose of the needed teaching didactics incorporating problem solving, merely share information instead of guiding learners towards self-discovery. Those teachers who have not taken an interest in the subject dynamics are not able to assist learners and guide them towards developing skills to progress. The next chapter reports on the research methodology used to conduct this study.

Chapter 3: Research Methodology and Design

3.1 Introduction

Through the literature study in the previous chapter, a baseline was used to conduct this research design and analysis and the emphasis and focus were on the qualitative and quantitative methods of the investigation.

This study used a mixed-method technique and the pragmatism paradigm. This method is based on the premise that by examining ideas' "transferability" to different contexts, they can be contextualized and generalized. It is centred on the main principle that by emphasizing the benefits and drawbacks of each style of study, qualitative and quantitative methodologies can enhance one another.

For achieving common understanding and coordinated action, Morgan (2007) emphasizes the complementarity of qualitative and quantitative methodologies. The separation between "total objectivity" and "complete subjectivity" is disrupted by mixed-methods integration, which creates "shared meaning" that encourages inter-subjectivity (Morgan, 2007).

A "system of ideas and practices that impact how researchers choose both the research questions they explore and the methodologies they employ to study them" is referred to as a research paradigm (Morgan, 2007, p.49). The term paradigm is used to characterize the researcher's worldview that guides the interpretation or meaning of research results in educational research (Kivunja & Kuyini, 2017). The word paradigm, whose origin is Greek, and which denotes pattern, can be characterized as a philosophical mode of thinking. The nature of the study's research challenge, goals, and questions is diverse.

This chapter presents research methodology that has been used in the study to answer research questions. The research, in this section, has put into context an outline that provided a theoretical framework of the research design, research method rationale, data collection strategy, and how data will be analysed. This will lead to describe the approach used in the research, including a case study through document analysis of the teaching strategies expected to be used or being used. The discussion of how data was collected and analysed is also explained.

In other words, the main sections of the study's methodology are described in detail in this chapter. It begins by generally stating what the chapter is about, i.e., an introduction. It further defines the term "methodology" in the context of a study. And then, provides a description of the study's geographical context. It also evaluates the study's research design. It continues to describe the research ethics that were used in the study. Finally, it provides a chapter summary.

3.2 Research Methodology

In this chapter a discussion of the mixed-method approach was done, which involves both quantitative and qualitative data collection and analysis. The data collection method that has been used to collect data is structured questionnaires (open-ended for educators and close ended for learners) and interviews to a focus group of educators.

Conrad & Serlin, (2011) stated that the mixed methods approach, as a combination of both qualitative and quantitative methods seems to be a way that attempts to close the gap in addressing how to they differ in terms of a research question. Collection, analysis, and interpretation of quantitative and qualitative data in one study or in several studies in investigating a common underlying phenomenon has been reported as another way of conducting a mixed method (Leech & Onwuegbuzie, 2006. The researcher will have to mix or bring together various approaches to gain an insight knowledge into the positives and negatives of quantitative and qualitative research method. Christensen and Johnson (2012:51) supported this idea by emphasizing that the mixed methods approach will assist in the improvisation of the quality of the research, since various research methods leads to varying strengths and varying weakness of the study.

Meanwhile, Mertens (2010), stated that data collection in the qualitative and quantitative research may happen in different forms, either parallel or sequential. While sequential form, a basis for collection of one type of data to another type of data is determined, in parallel form collection of all data are done at the same time. In parallel form, the researcher conducts the document analysis, both quantitative and qualitative data collection. Advantage of sequential form is that collection of quantitative data in the form of questionnaires first and thereafter open-ended questions survey can be done as a collection of qualitative data.

Researchers who design a mixed methods research have choices for opting to use any of the four natures or forms of mixed methods designs which are triangulation, embedded, explanatory, or exploratory (Creswell, 2008). Creswell (2008) also stated the ability to shift sequential designs through triangulation which involves in which both quantitative and qualitative data are used in the determination of where the findings will converge. The researcher in this study therefore used sequential design.

The researcher focused on research technique, research design, sampling method, and sample size, validity, reliability, and targeted the teaching and learning of kinematics using algebra knowledge in high schools within Free State Province in South Africa. Tools and methods that have been known to collect data is more quantitative in the form of questionnaires. The qualitative approach was used in the form of open-ended questions survey which was done to a focus group of educators. The questions in the open-ended survey are based on the questionnaires.

The study was chosen to investigate high school physical science educators' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics. It is therefore imperative for educators to understand the conceptual knowledge of their learners and learners to understand the pedagogical content knowledge of their educators. This will create a common understanding and ground for embedded knowledge transferred from educators to learners and enhance in the improvement in learners' performance and interest in the subject.

3.3 Research design

The proposed design includes data acquisition, procedures, data processing, funding sources (but not a budget), mathematical methods, computer methods, etc.

The research design is composed of a decision that research pursue in order to gain information or data, and how to examine that collected data by relaying answer that explores and addresses the set expectations, the research questions (Rajasekar, Philominathan and Chinnathambi, 2013). It is also defined by Fouché, Delport and De Vos (2011) to be an efficient measure of a strategy that a researcher intends to follow, to be in line with and meet the research intentions.

The researcher used a mixed method approach consisting of a quantitative part that utilizes closed questionnaires and a qualitative part in which focus group discussions will be conducted. The classification of mixed method research according to Creswell, Gutmann, Hanson & Plano Clark, (2003) is split into four categories of design, viz., the convergent parallel design; the explanatory sequential design; the exploratory sequential design, and the embedded design. Creswell et al. (2003) describes sequential design as collecting and analysing quantitative data to address the research questions. Following this, is the resulting collection and analysis of data through qualitative method. The results of quantitative data determined the qualitative data. Hence the researcher collected data quantitatively before collecting and analysing qualitative data.

As part of research design in mixed methods research, which is a combination of both the qualitative and the quantitative methods (Christensen & Johnson, 2012), was used to conduct this research. Non-experimental descriptive survey was used to collect data as a qualitative measure, i.e., the researcher investigated the quantitative and qualitative aspects of research design. This was to examine occurred events and their relationships without interfering with conditions that lead to them (McMillan and Schumacher, 2006).

Babbie and Mouton (2006), addressed a research design as a scientific enquiry planning, which is about a complete measure to investigate something. The three aspects that are usually incorporated in a research design, include the research approach, the research strategy, and the research methodology.

According to Wisdom and Creswell, 2013, the term “mixed methods” refers to an emergent methodology of research that advances the systematic integration, or “mixing,” of quantitative and qualitative data within a single investigation or sustained program of inquiry. The basic premise of this methodology is that such integration permits a more complete and synergistic utilization of data than do separate quantitative and qualitative data collection and analysis.

Of the four basic mixed method designs, viz., the convergent parallel design; the explanatory sequential design; the exploratory sequential design, and the embedded design (Creswell, Gutmann, Hanson & Plano Clark, 2003) the researcher will opt for explanatory sequential design. This will help the researcher to collect and analyse

quantitative data that address the study questions and a follow-up interactive qualitative data (Creswell et al., 2003).

The conceptual framework was guided by the literature review. Literature review will also guide towards the design of the educator' questionnaire. Possible document analysis as well as questionnaires and follow-up interviews were used for the purpose of this research.

The study will follow epistemological, and constructivist approaches according to interpretivism. The study will follow how people interrelate; their ideas are constructed around the environment (Thomas, 2009).

3.3.1 Data Collection Instrument

Data was collected using separate questionnaires, one for Grade 11 learners and all FET Physical Science educators. In most schools, there was one Science educator teaching all Grade 10 to Grade 12 Physical Science. If a school has more than one Physical Science educator, the school uses rotation system annually. The topic on kinematics starts in Grade 11 and hence all Physical Science educators were able to take part in the study.

In this study, learners were given a questionnaire, closed ended, consisting of related topics in Linear functions and graphs (algebra) and in Kinematics graphs and equations (one dimensional motion in physics). This will be followed by focus interviews with a sample of learners who responded to the questionnaire to determine whether they could integrate their algebraic and kinematics knowledge.

Another questionnaire (open-ended) was administered to Physical Science educators to determine what could be a problem with learners' poor performance in kinematic graphs and equations. This was because previous studies (Basson, 2002; Beichner, 1994) turn to blame educators for learners' poor performance in mathematics and physical science.

Teaching and learning in one of the traditional ways have reported that most teaching is based on the view of the instructor, teacher- centered, of the subject and how the teacher perceives his/her learners (Broadbent, B., 2021). The fact that learners are not active participants is a disadvantage in terms of the process of abstraction and generalization. Inductive thinking and inductive reasoning therefore lack the ability to

reason qualitatively and are unable to apply concepts during the learning process (Phage, 2015 and McDermott, 1999).

The study has been prompted by the fact that the majority of introductory Physics university students at CUT have been found not to be able to use or to link to these mathematical knowledge and skills in presentation their experimental laboratory reports. The probe of these learners' difficulties and deficiencies has given an indication that there could be remedial action which could help in alleviating these problems.

The research was based on two sets of separate questionnaires, one for high school learners and the other for their educators. The questionnaires were probing their perceptions on the learning and teaching of kinematics graphs and equations using the knowledge and skills of algebraic graphs and functions. The questionnaire for the learners was content based, determining how they learnt compared to how they were taught while the questionnaire for the educators was pedagogy and or methodology based, i.e., on the teaching and learning strategies.

The questionnaires for the learners were composed of two sections related to graphs. Section A was comprised of linear functions and graphs in mathematics whilst section B was on kinematics graphs and equations in introductory physics. All willing Grade 11 physical science learners in the selected school in the Free State Province (FS), South Africa (SA) were administered with this questionnaire to respond to it.

Through the literature study of the previous chapter, a baseline was used to conduct this research design and analysis and the emphasis and focus were on the qualitative and quantitative methods of the investigation. 'Test of Understanding Graphs in Kinematics (TUG-K)' model by Beichner (1994) was used to design Section A of the learners' questionnaire and Section B was deduced from it. Problems were reported to be due the fact and tendency that of physics undergraduate lecturers tend to make a wrong assumption of using graphs as second language, expecting undergraduate students to extract most of the rich information content from it (Phage, 2015; Beichner, 1994). This tendency seemed to have been passed on to and adopted by the physical science educators during their pre-service and in-service teacher trainings era.

Phage (2015) citing Beichner (1994) continued to state that tertiary students, including student teachers who qualified as physical science professionals, did not have fluency

of using graphs or graphing skills from their algebra (mathematics) knowledge, during their undergraduate training or education. It was hence that physical science educators need to accept that their learners must have a graph comprehension in order to use it as instruction language. Beichner (1994) therefore recommended that physical science educators should be able to use graphs for their learners' understanding and knowledge of the meaning of kinematic variables.

Beichner (2003), with regard to kinematics graphing, designed a questionnaire in the determination of the level of interpretation and analysis of kinematics graphs and therefore suggested possible teaching strategies of this topic. It is hence the researcher used his questionnaire to serve as an evaluation tool in this empirical study and the high school learners' misconceptions were compared with the findings of Beichner to be summarized in the next chapter.

3.3.2 Population and Sample

According to Omair, (2015), the need to select a sample depends on the sample size, which depend on the population size, and the probability sampling technique (e.g., ran must be used. Circumstances surrounding the estimation size of sample include the desired precision or accuracy, standard deviation, population size, and confidence level (Omair, 2015).

The population for this study was comprised of Grade 11 physical science learners and the high school/Further Education and Training (FET) physical science educators. The study could not be done with all FET physical science educators and learners in the province or in the country due to budget constraints. According to Alston (2020) and Yegidis & Weinmach, (2002), the purpose of the sample is to try and comprehend the population from which it comes in the hopes of drawing conclusions from the population.

A sample was selected out of proportion of population as according to Best and Khan (2003) was used to do the observations and analysis. This study was made of a target population of high school physical science educators and Grade 11 learners in three districts of the Free State Department of Basic education (FS DBE). The researcher found such a sampling as a fair and accurate representative of the target population (Omair, 2014; Charles & Mertler, 2008; Takona, 2002) to conduct this study, and would be enough to give a conclusive report.

The target population consisted of the high school physical science educators and learners in the Free State Province, South Africa. The sample was made of 33 out of 166 high schools physical science educators within three Districts out of eight. A minimum of two educators per school was targeted but there was only one physical science educator per school. It was not feasible to work with all schools in these districts and in the province due to COVID-19 pandemic, cost measures and too much travelling between schools.

Purposive sampling, according to Pandey and Pandey (2021) citing Kerlinger (1986), is a different kind of non-probability sampling in which the criteria used to pick the participants are more significant than the quantity of participants, and the qualities of the participants serve as the foundation for selection.

Therefore, purposive sampling was chosen from this population, and it was limited to certain schools in the Motheo, Xhariep and Lejweleputswa Districts in the Free State Province, South Africa. Convenient sampling was conducted to choose physical science FET Grade 11 learners and educators in certain schools in these districts for both quantitative and qualitative research. There were 301 learners and 33 educators who participated in the questionnaires as well as 6 educators who were interviewed.

3.3.3 Sampling Technique

To be objective in the research, it is imperative that the researchers must ensure it by doing a careful and specific sampling and research techniques. The critical outcome to be approach will therefore place an emphasis to determine for who the curriculum, interest and assessment criteria will serve and be designed accordingly (McKenna, 2010). It is for this reason that the researcher in selection of schools in the study, that he has to consider several factors. But due to financial constraints and avoid too much travelling since most schools are in the rural areas, the researcher limited the sampling to public schools, doing mathematics and physical science within the three Districts, viz., Motheo, Lejweleputswa, and Xhariep to conduct this study. Permission to conduct research was obtained by sending out letters to Districts offices, school principals, learners and educators. Preliminary visits to school principals were done to explain the importance of this research and to induce their interests to participate in this research.

Convenient sampling of purposive group, made of Grade 10 – 12 (high school) physical science educators/educators, was used in the administration of the questionnaire.

A purposeful sampling was also used in selecting schools offering physical science in the Free State province. Only schools offering physical science in the province district will form part of this sample. In the quantitative research, convenience sampling was used to select the Grade 12 physical science educators in the Motheo district. Only a few schools offering physical science in the Motheo district was targeted in the qualitative research.

3.4 Procedure

Learners and educators were given questionnaires to complete. The questionnaire for learners will use relevant questions adapted from Phage (2015) and Beichner's questionnaire on kinematic graphs (Beichner, 1993). From this questionnaire an equivalent questionnaire will be devised in the context of algebra also adapted. From Phage (2015) questionnaire. The questionnaire for educators was derived and adapted from TIMSS questionnaire (Angell, Lie, and Rohatgi, 2011 and Martin, 2000) which determines their learners' conceptual understanding and use of previous knowledge as well as how they use the pedagogical transmission of knowledge and teaching to enhance their learners learning of the concept. The data of the two questionnaires will be analysed statistically to compare the learners' and educators' responses and to determine their ability to transfer their knowledge to a physical context.

After processing the questionnaire, focus group interviews will be held with three groups of three educators each to investigate how they reason and link information. The group discussions will be observed, transcribed, and analysed for patterns and trends in the data. Funding of statistical processing of the quantitative data will be paid by the funding from university grant.

3.5 Instrument

The study's equipment included an interview schedule and a diagnostic questionnaire. Researchers have access to a robust data collection technique and an outstanding array for collecting numerical data during diagnostic tests rather than verbal data (Mills

and Gay, 2016). According to Lambrianou (2009, p.2), "diagnostic questionnaires are tools used in educational research and involve a series of questions or tasks that are focused on a certain topic and are supposed to be completed by students".

3.5.1 Questionnaires

The research did both the pre - test and post - test research designs to determine the perceptions of grade 11 learners and their educators on the learning and teaching of kinematics graphs and equations using the knowledge and skills of algebraic functions and equations. The learners were asked from the conceptual knowledge and understanding whilst the educators were asked on the pedagogical or teaching methodology point of view, from which and thereafter follow up interviews or class visit were conducted.

These questionnaires, interviews and class visit also helped to scrutinise (policy document analysis) on how effective the CAPS intervention is and how effective was the transition from OBE to NCS and to CAPS. This might help in trying to develop instructional materials to address the teaching and learning of kinematics graph.

The questionnaire for learners was designed on kinematics concepts and graphs, compiled from relevant questions from Beichner's standardized questionnaire on kinematic graphs (Beichner, 1994) as a basis, and corresponding linear algebraic graphs and functions (Phage, 2015). The sample study was comprised of Grade 10 – 12 educators within the Motheo district, Lejweleputswa, and Xhariep Districts. Permission to conduct this research was sort and obtained from the relevant Department of Education authorities, the Free State Department of Basic Education.

The questionnaire for the educators was a combination of questions obtained from the teacher questionnaires in the Trends in International Mathematics and Science Study (TIMMS 2008) and Progress in International Reading Literacy Study (PIRLS 2006). The respective interviews were deduced from the responses of the educators in this questionnaire. The policy document analysis was based on the current Curriculum and Assessment Policy (CAPS) for Further Education and Training Phase (Grade 10 – 12) in Physical Science (CAPS, 2012)

3.5.2 Observation

The questionnaires were administered to the grade 11 physical science learners and their respective educators accordingly. The responses were obtained and recorded

for analysis. The follow up interviews, class visit, and policy document analysis were also recorded for observation and data analysis.

The researcher would request to accompany the educators to the classes when teaching kinematics and observe the lesson. Policy documents will be scrutinized to determine how effectively are the educators using it and how effective (strategies used) is it in the learner comprehension of the concepts they learn and taught.

The data of the kinematics and algebraic concepts in of the questionnaire were used for statistical analysis to establish what deficiencies as well as the logical, consistent and application of the learners' understanding or knowledge. The data on educators' pedagogical content knowledge of the concepts in kinematics and algebra were used to their relation to their learners' comprehension and relation to what they learners are expected to know or what learners expect from their educators.

The data collected was sent to statistician for data analysis and interpretation. This was after it was recorded and coded. The service of a student assistant was utilised in recording the coded data.

3.5.3 Data analysis

Data collection was done in three ways, viz., through questionnaires, focus interviews with learners only and policy documents was analysed as obtained. Since the questions in questionnaire for educators were open-ended, the researcher felt their responses were explicit enough.

This study was both quantitative and qualitative study based on a data resolution methodology with the aim of analysing perceptions high school learners' graphing skills and conceptual understanding as well and their educators' teaching strategies by exploring how they related these variables while drawing and interpreting kinematics graphs. For the analysis, a scoring scheme was developed to measure learners' performance and educators' responses.

The policy documents on the teaching and learning of kinematics was analysed qualitatively to determine how the educators are using it and if there are any indifferences or variations on the approach to teaching.

The entire set of data collected for this study was analysed using computers, calculators, and the Statistical Package for Social Sciences (SPSS). Data analysis

involves being familiar with the data, reducing it, organizing it, breaking it down, and synthesizing it. It also involved generating codes and themes, looking for patterns and contrasts, and building blocks (Bazeley and Jackson 2013:04).

The purpose of this activity is to provide context for the data that the researcher has gathered and assembled (Singh 2006:224; Driscoll 2011:17). The researcher begins by coding, then tallies the results to put the data into numbers (Ary et al. 2010:123). Combining univariate and bivariate analyses, this provides information for descriptive statistical analysis. The researcher guarantees utilizing intervals, that bar charts and histograms tables. In terms of frequency, the characteristics and constructs on the algebraic and kinematic concepts and learners' difficulties are unequal. At this point, the researcher applies ratio and ordinal scales to the processed data to create patterns and contrasts (Ary et al. 2010:123).

Before statistical analysis was done, coding of responses from participants (data) was done. Coding had started right away after becoming comfortable with the data. This was accomplished by segmenting the data and putting responses on a nominal scale. Thematic analysis was then performed after codes, which emerged from primary data even though the researcher had never imposed them (Kumar 2011:248; Walliman 2011:134). Following that, the act of tallying manifested and created frequencies that made it possible to draw conclusions with internal validity. In semi-structured interviews, if there are some variables with a commonality boosting data reliability, qualitative data are mostly elicited.

In addition, because some respondents' responses were not homogeneous, partial questions' openness helped to increase validity by allowing for the flexible collection of important data (Walliman 2011:134).

The researcher has in fact created blocks by comparing equivalent units of analysis across the study districts using qualitative and quantitative data. Each of which includes an overview, an explanation, and an introduction to its statistical findings. The statistical presentation of data based on nominal scale through coding then enters the picture.

3.5.4 Interviews

A small number of teachers, at least 3 per District, was used to do focus interviews to validate and authenticate the rationale behind their responses in the questionnaire. A

consent was also obtained from this education with total privacy and confidentiality maintained.

The researcher has used notetaking because it has advantages over computerized methods, such as the ability to record just pertinent information and save time for transcript processing. This was selected from a variety of recording methods, including two electronic (audiotape recorder) and one manual (taking notes) (Cohen et al. 2007:365; Driscoll 2011:165). The researcher's strong interpersonal and communication abilities are crucial for both verbally eliciting data and presenting it in writing. However, taking notes might introduce subjectivity or prejudice, which may have a detrimental impact on the validity of the results. To mitigate this, the researcher writes responses since they reflect the objective component of real research.

3.6 Data collection

” It is hard to find an article that deals with the generic issues related to the quantitative and qualitative divide by drawing on distinguished research literature. Interested in addressing this need, this article aims to explain the essential characteristics of quantitative and qualitative research approaches with an emphasis on their underlying epistemological, theoretical, and methodological differences. It elucidates the research design issues and concepts in relation to both research paradigms, from planning research to collecting and analysing data, and reporting findings.” (Yimaz,2013:311)

Data collection from research will determine existing conditions and identify standards to compare these conditions as well as determine their relationships with other specific events (Yilmaz, 2013; Cohen et al., 2011:256). In his study, Phage (2015), reiterated aspects of investigation that he named tasks characteristics and summarised them as:

- What or how much previous knowledge in algebra and kinematics can learners recall in the questionnaires
- if learners are able relate algebraic expressions and graphs with those in in kinematics
- if learners will be able to extrapolate the algebraic variables from a given graph
- if learners can name and relate those variables in algebra with those in kinematics

- if learners do use rote knowledge in the kinematics questions or do, they show a proper understanding of kinematics terminologies and knowledge.

This study followed the same route in the measures of investigation with these high school learners and used to collect data.

The educators' pedagogy as well as their teaching strategies will be observed and investigated where they agree with their teaching philosophies and practices. A reflection of these two aspects from will be a guiding factor for their perception inside and outside the classroom.

Data collection for this study was made of responses from the questionnaires, document analysis and interviews. Based on available resources, it was decided on whether opened/closed questionnaire and structured or unstructured interviews. In non-experimental research, the participants, traits, scores, and characteristics are mainly defined and clarified without intervention while phenomenological research deals with the description and interpretation the experiences of the participants to have a clear perception of their understanding of their response (McMillan, 2008).

Two sets of questionnaires, one for Grade 11 Physical science learners and the other for their educators, were administered. From the responses of the educators, focus interviews were held. CAPS document for Grade 10 – 12 in Physical was examined and data collected from it for analysis.

The processes of interacting collection and interpretation of the same data, including its analysis plays a crucial and significant role according to Tracy, (2019) and Gay & Airasian, (2000). Therefore, and for this reason that quantitative and qualitative methods tend to complement one another to obtain more balanced and reliable findings. Quantitative approaches are objective since it gives finding in numerical format whereas while qualitative approaches which are more subjective for the interpretation of the research data and is given in words (Dahlberg and McCaig: 2010; Taylor, Trumbull & Watson, 2010). It is for this reason that Creswell, and Poth, (2016) reported qualitative approaches as involving inquiry learning and help in the exploration of problems that are human and social related.

Three criteria have been reported to emerge in the judgement of the quality of measuring quantitative research (Ellingson, 2017; Mertens, 2010). Those criteria are reliability, validity, and objectivity. According to Johnson, (2014) and Edmunds &

Scudder, (2009), there are five criteria mentioned under the critique of qualitative research and are known as credibility, dependability, conformability, transferability, and authenticity. All the criteria are the core measures of any reputable research study.

3.6.1 Reliability

Reliability according to Mabotja, (2017) and Cohen et al (2000) has been defined as the measure to test a procedure to give same results are taken when the conditions are not altered. In this study, researcher used it to measure how consistent were the responses or scores as determined by the instrument (Zohrabi, 2013; Fraenkel and Wallen, 2003). Various approaches would assist in the facilitation of reliability. These approaches, according to Hart & Laher, (2015), Babbie & Mouton, (2001) and Neumann, (2000) are in the form of triangulation, cross-examining, member checking, consensus, and mechanising.

The researcher has placed his faith on methodological triangulation analysis units when verifying consistency in terms of reliability. The variations in the questions allowed for reliability testing (Kumar 2011:168).

To ensure reliability in this study, the researcher designed questionnaires and conducted a pilot to identify and rectify the mistakes and uncertainties in those questionnaires. Internal consistencies of different questionnaire parts were measured by calculating the Cronbach's alpha (α) coefficient, for both learners' and educators, questionnaire.

The instruments used were trusted to provide reliable results. The techniques and procedures were also designed with precautionary measures and deemed to be reliable to produce the expected or required results.

As indicated in and under the ethical consideration of this research, a full attempt was done to ensure and account for provision of ownership of secondary information obtained through referencing of other authors' study to give reliability of this study.

To further ensure the reliability or trustworthiness of this study, the distribution of surveys and conducted interviews, the issues of bias in responding and duplicating one another's survey was accounted for to ensure that results are based on what has transpired and as observed by an individual, who is within the education system and is being questioned. The purpose is to reduce redundancy and inaccuracies in the data that is used to result in the required conclusion of the research topic.

3.6.2 Validity

The internal consistency of the participants' responses was also determined and specifically measured through or by using the Cronbach alpha. This helped to determine or account for differences in the way they responded to a specific statement. A research instrument and paradigm were developed and structured to accurate and reliable data in this research study. The research instruments can be scrutinized and restructured as a norm in all research studies to give the certainty for validity and reliability.

The data collected was quantified as measure or attempt to employ quantitative strategies and systems as part of this mixed method research. The questionnaires were thus sources of instrument to do this. Qualitative method of this research implored collecting data through interviews and document analysis. Both strategies and techniques provided the data that could be used as, and proven to be accurate, reliable, and valid.

Even when collecting qualitative data, the researcher considered and applied validity and dependability with the goal of upholding scholarly respect. When validating data, the researcher first considered the study's specific goals and research questions, matching them logically with the field questions (face validity) (Kumar 2011: 167). The researcher then used a variety of field questions to obtain information to fulfil the study's content validity focus (Kumar 2011:167). The researcher should clearly identify the degree of variables showing levels of measurements for curiosity and curricular relevancy to the teaching and learning (pedagogy) and relation of algebraic and kinematics graphs – construct validity (Kumar 2011: 167) – for advancement seek based on the data obtained.

3.6.3 Forms of Validity

According to participants' responses in the pilot study, the researcher found out that the criterion of the questionnaire was valid and relevant to the study. The instrument used showed that the data collected were evident enough to conduct the study. Confidence and efficiency were more evident from science educators who indicate a high professionalism in their duties that they can plan and prepare fully plan and prepare for their lesson as well as in the facilitation of practical work and its teaching, and assessments of all forms.

The content chosen in terms of the construct for conceptual understanding and pedagogics of the kinematics graphs in relation to algebraic graphs were found to be relevant and reliable for the purpose of this research. The data collected from these were evident enough to give the required results.

3.6.4 Trustworthiness

For trustworthiness and since study used a mixed method that is explanatory, a general picture of research problem was deduced from qualitative data and participants' responses. The data collected refined, extended, and explained general view of the study. The Convergence and integration of two various forms of data, qualitative and quantitative, were therefore not required or must be used by the researcher. It is only that qualitative data require intensive labour, consume time in the collection of both quantitative and qualitative data, and expertise knowledge. This is mainly required in the research design, both qualitative and quantitative data according to Creswell, (2013).

It is hence a mixed methods approach is appropriate for this study in establishing a relationship between the biographical data of the participants, to what extent are they prepared in Science and Science teaching or methodology. The trustworthiness of the research therefore largely depended on this aspect being addressed and taken care of. It is thus, the chosen research method is suitable for evaluating the self-efficacy of science instructors in this study, since it examines their assessment abilities, topic knowledge, and demographic characteristics as independent variables and their correlation with efficacy. and teaching preparedness/methodologies were deduced. The significance and trustworthiness of responses based on their environmental conditions were thus understood (Engdahl, & Lidskog, 2014; Welman *et al.*, 2005).

3.7 Pilot Study

Pilot studies are scaled-down variations of the main study that are conducted in the advancement of it (Creswell, 2016). The terms feasibility studies, baseline studies, and trial runs are occasionally used to describe pilot studies. A pilot study was conducted in this study to evaluate the diagnostic questionnaire and interview schedule. Thirty-one (31) learners from the population who did not participate in the study's sample space were used for the instruments' pilot testing. A pilot study has the benefit of highlighting any potential pitfalls, protocol issues, or inappropriate procedures and

instruments that might emerge in the main project. The responses from the respondents were used to evaluate the feasibility of the study, the sufficiency of the research equipment, and statistical and analytical techniques.

The diagnostic questionnaire's time limit was increased from one hour to two hours in response to comments from the pilot research, which indicated worry about the lack of time to proofread the answers, finish the exam and the ability of learners (participants) to enjoy the questions. The questionnaire was administered to research participants in both the pilot and the main study in the same manner. Following an interview with twelve learners (participants), the necessary modifications were made considering the comments and the findings. For each interview, the time was cut from 40 to 10 minutes. Educators were not interviewed because the responses were more open-ended.

3.8 Data analysis procedure

Data was, compiled and obtained from the responses of the questionnaire and interviews as well as from the policy document. Interview responses, a qualitative approach, was obtained after obtaining questionnaire responses from the educators. Interview responses and lesson observation were first transcribed, coded and analysed. The responses of the questionnaire were analysed using the descriptive and the inferential statistics to understand and identify common characteristics, concerns and issues pertaining to teaching and learning graphs in algebra and kinematics in high schools within Motheo Region.

Finding the mean, standard deviation, lowest and maximum score values, and creating charts were all covered in descriptive statistics. The Statistical Package for Social Sciences (SPSS) was used to analyse the data. Interviews' qualitative data was collected on tape and transcribed. All the audio files that were recorded were faithfully transcribed. A classification of explanations and scientifically completed responses (nomothetic) were used to analyse participants' responses (ideographic).

This research involved obtaining the findings by processing analysed data and its interpretation. The study will categorise collected data from quantitative and qualitative approaches by factoring and relating them into teaching and learning of kinematics using algebra within high school system and curricula.

The researcher will also summarise the investigation and further study interpretation together with recommendation and a conclusive report. The recommendation of the study will be based on the conclusion of the deduced findings and results towards maximal use of teaching and learning of kinematics using algebraic knowledge and skills in the Further Education and Training (FET) Phase schools of the Department of Basic Education.

The pre- and post-tests percentages were calculated for the responses given to multiple-choice test items in the questionnaires. In addition, one-way ANOVA was carried out to determine whether there are significant differences based on grade level among the test mean scores of the participants, learners, and educators separately. On the second stage, descriptive analysis of the open-ended questions was carried out and, in this way, the graph types in which the pre-service teachers have greater success in reading and interpreting and the difficulties they often encounter while reading graphs were determined.

In addition, one-way ANOVA was carried out to determine whether there are significant differences based on grade level among the test mean scores of the preservice teachers. On the second stage, descriptive analysis of the pre-ended questions was carried out and, in this way, the graph types in which the pre-service teachers have greater success in reading and interpreting and the difficulties they often encounter while reading graphs were determined.

To analyse data collected through descriptive and inferential statistics, the researcher used the Statistical Package for the Social Sciences (SPSS version 20).

Tanner, (2012) referred to descriptive statistics as the type and quantity of data varies and being calculated to determine the essential characteristics sets of data and not refer to each of the individual measures. This incorporates factors like standard deviation, the mean, percentages, frequencies, and frequency distribution.

There are three advantages of descriptive statistics:

- give a general descriptive indication of the variables that must be used in this study
- to give data that can be distributed in or order to be in line with assumptions for doing inferential statistics,

- to examine the relationships between dependent and independent variables in this study. Further independent variables were also used in this study which are the type of school, geographic location of the school, gender, age, educators' teaching experience in physical science, and educators' qualification, educators' pedagogical content knowledge, and their assessment skills.

In terms of inferential statistics, the population indices are inferred based on the corresponding indices resulting from the random sampling in the population according to Welman, Kruger & Mitchell, (2005). Tanner, (2012) reiterates that the domains of these statistics in quantitative data analysis help to determine the larger group from characteristics of smaller group.

3.9 Limitations

The study was conducted with high school physical science educators and Grade 11 learners in three Districts of Department of Basic Education, Free State Province for cost and logistical purposes. The researcher focused only on the perspectives in the teaching and learning of kinematics graphs and equations using algebraic knowledge and skills of graphs and function including their problem solving. Interviews were only done with a focus group of these educators who participated and responded to questionnaire.

3.10 Delimitations of the study

The study was conducted within one province in South Africa, out of nine, and within three districts of that Province, Free State. Not all schools in these districts participated in the study due to several reasons, e.g., COVID-19 restrictions in the schools, backlog in the learners' schoolwork, rotation system for attendance of learners, long drives/travelling within schools, time, and cost factors, etc. Data collected in the participated schools gave enough evidence to conclusive results though limited to these districts only within the province.

3.11 Ethical considerations

The completion of questionnaire and interviews by participants in the study was voluntary and all participants completed a consent form without any improper

influence. Since participation was voluntary, participants had the choice not to respond to any questions they were or felt uneasy to answer (Kumar, 2019).

Permission was sought and obtained from Free State Department of Basic Education, school Principals, learners, and educators (from FET physical science schools) as well as learners' parents to complete the questionnaire with total confidentiality and privacy. It was hence participants did not have to disclose or write their names and that of their schools on the questionnaire.

The study was authorised by the Central University of Technology, Free State (CUT) as permission was sought and obtain through the Ethics Committee of its Faculty of Humanities.

The participants were informed that the results were strictly for research purpose and not to single out any individuals or schools and it will mainly be used to enhance and support teaching and learning of kinematics graphs and equations. While gathering, analysing, and reporting data, confidentiality and anonymity are ethical procedures aimed at protecting the privacy of human subjects. They safeguard the privacy of research participants who willingly consent to take part. Participants feel more at ease filling out surveys or taking part in interviews if they have some confidence that the researcher won't expose the information they've provided (Creswell, 2016).

Participants were also well informed of the significant and valuable contribution they would make by taking part in the investigation of the teaching and of physical sciences using the knowledge skills learnt in algebra, mathematics.

"Informed consent is a process that entails informing the subject about his or her rights, the objective of the study, the procedures to be followed, and the potential risks and advantages of participation," claim Macmillan and Schumacher (2010. 198). With the primary objective of allowing participants to make an well-informed choice on the matter their participation in the research or withdrawal, the informed consent procedure was thoroughly described to the participants accordingly.

3.12 Conclusion

In this chapter the researcher was looking at the research design methodology he will be utilising to arrive at the research objectives of this study. The researcher elaborated the definitions of pedagogy in the context of teaching and learning of FET kinematics

and algebra curriculum and discussed the mixed method approached he used for this study. Including the way data was collected and was analysed. He further described the sample and population tools he used and explained the statistical approached approaches in the finding and how he will arrive at the conclusion and study implications.

The study's research design and the rationale of the mixed-methods research paradigm as a method for figuring out the teaching and learning of algebraic and kinematics graphs were covered in this chapter. The students' interpretations were examined utilizing interviews and descriptive statistics analysis done with SPSS. Finally, ethical issues were brought forward and talked upon. In Chapter 4, the study's findings will be presented and reported.

Chapter 4: Findings and discussion

4.1 Introduction

This chapter's objective is to highlight the study's new findings, i.e., mainly to focus on the presentation, analysis, and interpretation of the obtained research data. The analysis and interpretation of various kinds of data are also covered in this section mainly ensure to address the research questions in this study. The research approach was addressed in the prior chapter. This chapter, therefore, presents an analysis of the data, its findings, and outcomes, all of which are focused on the specific research questions and goals listed in chapter 1 of this study (Eiffel Corporation, 2006; Zhang et al., 2013).

As reiterated in chapter 1, purpose of the study was to establish from the chapter 2, the literature review, from the perceptions of educators and learners if there is a relation in the teaching and learning of kinematics graphs using the knowledge and skills acquired from algebraic graphs. It further meant to determine the actual teaching and learning approaches and practices in these concepts among Grade 11 learners, to verify and describe the current and actual state of teaching and learning kinematics graphs in the Grade 11 FET Phase within selected Free State schools through separate questionnaires for both learners and their educators and to finally report on the implications of findings of the study.

4.2 Quantitative analysis of data – Educator's questionnaire

4.2.1 Demographics

A total number of 33 physical science educators from different schools took part in the study. The table below indicates the general demographics of the educators including their type of schools. The study indicated about 85% of educators are under the age of 40 (36.4% are 30 to 39 years, 27.3% are 25 to 29, and 21.2% are under 25 years). The respondents are dominated by males (60.6%), while 51.5% are Blacks, 24.2% are Whites, 15.2% are Indians and 9.1% are Coloureds. The type of schools was mainly township (semi-rural) at 42.4%, followed by semi urban townships but not model C at 21.2%, Model C's and villages both at 15.2% and farm schools at 6.1%.

The table below indicate results of demographics of educators in terms of age, gender, race, and type of school.

Table 4.1: Demographics of educators and type of school

	Age - A1	Gender - A2A	Race - A2B	Type of school - A3
Valid	33	33	33	33
Missing	0	0	0	0
Median	3.00	2.00	2.00	3.00
Mode	3	2	2	3

The high percentage of educators at 42.4% have a teaching experience of 3 to 7 years, 27.2% have 8 to 10 years, 15.2 % have less than 3 years and another 15.2 have more 10 years teaching experience. There was a high a high percentage, at 54.5%, with no mathematics teaching experience, 30.3% have less than 2 years, 12.2 have 3 to 8 years while 3% have more than 8 years of experience in teaching mathematics.

Most educators intended to continue teaching physics were at 69.7%, 18.2% were waiting for opportunity for better jobs in education to come along while 12,1% were undecided at that time. The majority of educators, 87.9%, believe that one need to teach mathematics also in order, and think that their mathematics knowledge will help them, to teach physics efficiently and effectively, 9.1% did not agree while 3% said to some extent.

- What are the perceptions of high school learners and teachers on the teaching and learning of graphs in kinematics?
- Which perceptions do high school teachers have on the teaching and learning of algebraic graphs in kinematics?
- How does physical science teachers relate the concepts in algebraic graphs and functions with concepts in kinematics graphs and equation?
- Do the national policy guidelines say anything regarding the teaching and learning of kinematics graphs in high schools?
- How does the background of high school physical science teachers impact on the use and applications of algebraic graphs and functions to solve kinematics graphs and equations?

4.2.2 Educators' perspectives on the content knowledge and pedagogics of teaching kinematics (physics)

The following tables below indicates the ratio of confidence educators must teach certain topics in physics:

Below is the confidence level in teaching "Mechanics".

Table 4.2.1 Mechanics

	Frequency	Percent
Somewhat confident	3	9.1
Very well confident	30	90.9
Total	33	100.0

Table 4.2.1 above indicate that 90.9 % of educators were comfortable and confident to teach the topic of mechanics while about 9.1% were not comfortable or do not have the confidence.

Below is the confidence level in teaching "Electricity and Magnetism".

Table 4.2.2 Electricity and Magnetism

	Frequency	Percent
Somewhat confident	3	9.1
Very well confident	30	90.9
Total	33	100.0

On the topic of electricity and magnetism, the same percentage of about 91% of educators do have the confidence to teach while only about 9% do not have that confidence.

Below is the confidence level in teaching "Heat and Temperature".

Table 4.2.3 Heat and Temperature

	Frequency	Percent
Somewhat confident	4	12.1
Very well confident	29	87.9
Total	33	100.0

The results shows that about 88% of educators have the confidence in the teaching the concept of heat and temperature while about 12% lack that confidence.

Below is the confidence level in teaching “Atomic and Nuclear Physics”.

Table 4.2.4 Atomic and Nuclear Physics

	Frequency	Percent
Not well confident	1	3.0
Somewhat confident	7	21.2
Very well confident	25	75.8
Total	33	100.0

The table indicate that in terms of the teaching of atomic and nuclear physics, about 76% of educators do have the confidence while only about 14% do not have that confidence.

4.2.3 The educators’ interactions with their fellow or other educators on specific aspects

The tables below indicate the rate of educators’ interactions with their fellow or other educators on specific aspects:

Below indicate educators’ discussions with other educators about how to teach a particular concept.

Table 4.3.1 Discussions about how to teach a particular concept.

	Frequency	Percent
Daily or almost daily	5	15.2
1-3 times per week	10	30.3
2 or 3 times per month	16	48.5
Never or almost never	2	6.1
Total	33	100.0

The results show that concerning discussions about how to teach a particular concept, about 49% do it 2 to 3 times a month, about 30% do it 1 -3 times a week, about 15% do it daily or almost daily, and only about 6% of them never or almost never do it.

The table below is on working with other educators on preparing instructional materials.

Table 4.3.2 Working on preparing instructional materials.

	Frequency	Percent
1-3 times per week	15	45.5
2 or 3 times per month	13	39.4
Never or almost never	5	15.2
Total	33	100.0

The results depict that 45.5% do it 1 – 3 times a week, 39.4% do it 2 – 3 times a month, and only 15.2% never or almost never do it at all.

The table below is on visits by educators to their fellow colleagues' classroom to observe their teaching.

Table 4.3.3 Visits to another teacher's classroom to observe his/her teaching

	Frequency	Percent
Daily or almost daily	1	3.0
1-3 times per week	13	39.4
2 or 3 times per month	11	33.3
Never or almost never	8	24.2
Total	33	100.0

From the table above, 39.4% do it 1 – 3 times a week, 33.3% do it 2 – 3 times a month, 24.2% never or almost never do it while only 3% do it daily or almost daily.

Below is the ratio of educators' informal observations of their classrooms by their fellow colleagues.

Table 4.3.4 Informal observations of my classroom by another teacher

	Frequency	Percent
Daily or almost daily	1	3.0
1-3 times per week	13	39.4
2 or 3 times per month	11	33.3
Never or almost never	8	24.2
Total	33	100.0

The results shows that 39.4% do it 1 – 3 times a week, 33.3% do it 2 – 3 times a month, 24.2% never or almost never do it while only 3% do it daily or almost daily.

4.2.4 Educators' participation in professional development

Educators were asked whether in the past two years (before participating in the study), if they have participated in professional development in any of the relevant aspects. The tables below show their responses per aspect.

Table 4.2.4.1 shows the participation of educators in the physics content professional development.

Table 4.4.1 Physics content

	Frequency	Percent
No	22	66.7
Yes	11	33.3
Total	33	100.0

Only one-third of the educators have participated in the professional development in physics curriculum while two-thirds did not.

The ratio of educators' participation in the professional development in the integration of information technology into physics is given in table 4.4.4 below.

Table 4.4.4 Integrating information technology into physics.

	Frequency	Percent
No	23	69.7
Yes	10	30.3
Total	33	100.0

The results show that only about 30% of the educators have participated in the professional development in the integration of information technology into physics while 70% of them did not.

The ratio of educators' participation in the professional development in improving learners' critical thinking or inquiry skills is given in table 4.4.5 below.

Table 4.4.5 Improving learners' critical thinking or inquiry skills.

	Frequency	Percent
No	22	66.7
Yes	11	33.3
Total	33	100.0

The results show that only one-third of the educator have participated in improving learners' critical thinking or inquiry skills while two-thirds of them did not.

The ratio of educators' participation in the professional development in the physics assessment is given in table 4.4.6 below.

Table 4.4.6 Physics assessment

	Frequency	Percent
No	23	69.7
Yes	10	30.3
Total	33	100.0

The results show that only about 30% of the educator have participated in the professional development in the physics assessment while 70% of them did not.

4.2.5 Aspects of the severity of certain problems in schools

On the aspects of how severe each of certain problems in their current school are, the educators had different views and their responses were analysed as follows.

Table 4.5.1 shows how educators feel the severity that the school building needs significant repair.

Table 4.5.1 The school building needs significant repair.

	Frequency	Percent
Minor problem	20	60.6
Not a problem	13	39.4

Total	33	100.0
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The results show that about 39.4% of education do not have a problem with the need for significant repair in the school building while about 61% believe the school building needs significant repair.

The table below shows how severe does educators feel about classroom overcrowding in their schools.

Table 4.5.2 Classrooms are overcrowded.

	Frequency	Percent
Minor problem	4	12.1
Not a problem	29	87.9
Total	33	100.0

The results indicate that only about 12% of educators saw classroom overcrowding as a minor problem while about 88% of them do not have a problem.

The table below shows how severe does educators feel about adequate workspace outside their classroom in their schools.

Table 4.5.3 Teachers do not have adequate workspace outside their classroom.

	Frequency	Percent
Minor problem	4	12.1
Not a problem	29	87.9
Total	33	100.0

The results indicate that only about 12% of educators saw adequate workspace outside their classroom as a minor problem while about 88% of them do not have a problem.

The table below shows how severe does educators feel about materials that are not available to conduct physics experiments or investigations in their schools.

Table 4.5.4 Materials are not available to conduct physics experiments or investigations.

	Frequency	Percent
Serious problem	12	36.4
Minor problem	8	24.2
Not a problem	13	39.4
Total	33	100.0

The results indicate that, concerning materials which are not available to conduct physics experiments or investigations in their schools, that only about 36% of educators saw it as a serious problem, 24% of them as minor and about 39% of them do not have a problem.

4.2.6 Characterisation of certain aspects within the school

The following tables shows the analysis results of how they would characterize each of certain aspects within their school.

The table below shows the results of analysis of how educators characterise job satisfaction.

Table 4.6.1 Teachers' job satisfaction

	Frequency	Percent
Low	13	39.4
Medium	20	60.6
Total	33	100.0

The results indicate that about 39% of educators characterise their job satisfaction as low and about 61% of them characterise it as medium.

The table below shows the results of analysis of how educators perceive their understanding of the school's curricular goals.

Table 4.6.2 Teachers' understanding of the school's curricular goals.

	Frequency	Percent
Medium	15	45.5
High	18	54.5

Total	33	100.0
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The results indicate that about 55.5% of educators perceive their understanding of the school's curricular goals as high and 45.5% of them characterise it as medium.

The table below shows the results of analysis of how educators perceive their degree of success in implementing the school's curriculum.

Table 4.6.3 Teachers' degree of success in implementing the school's curriculum

	Frequency	Percent
Medium	15	45.5
High	18	54.5
Total	33	100.0

The results indicate that about 55.5% of educators perceive their degree of success in implementing the school's curriculum as high and 45.5% of them characterise it as medium.

The table below shows the results of analysis of how educators perceive their expectations for learner achievement.

Table 4.6.4 Teachers' expectations for learner achievement

	Frequency	Percent
Low	8	24.2
Medium	20	60.6
High	5	15.2
Total	33	100.0

The results indicate that about 24% of educators characterise their expectations for learner achievement as low, about 15% as high and about 61% of them characterise it as medium.

The table below shows the results of analysis of how educators perceive their support for their professional development.

Table 4.6.5 Support for teachers' professional development

	Frequency	Percent
Very low	17	51.5
Low	16	48.5
Total	33	100.0

The results indicate that about 51.5% of educators characterise their support for their professional development as very low and about 48.5% of them characterise it as low.

The table below shows the results of analysis of how educators perceive the need for parental support for learner achievement.

Table 4.6.6 Parental support for student achievement

	Frequency	Percent
Very low	18	54.5
Low	10	30.3
Medium	5	15.2
Total	33	100.0

The results indicate that about 55% of educators characterise the need for parental support for learner achievement as very low, about 30% of them characterise it as low and only about 15% of them as medium.

The table below shows the results of analysis of how educators perceive the need for parental involvement in school activities.

Table 4.6.7 Parental involvement in school activities

	Frequency	Percent
Very low	19	57.6
Low	9	27.3
Medium	5	15.2
Total	33	100.0

The results indicate that about 58% of educators characterise the need for parental involvement in school activities as very low, about 27% of them characterise it as low and only about 15% of them as medium.

The table below shows the results of analysis of how educators perceive learners' regard for school property.

Table 4.6.8 Learners' regard for school property

	Frequency	Percent
Very low	18	54.5
Low	10	30.3
Medium	5	15.2
Total	33	100.0

The results indicate that about 55% of educators characterise learners' regard for school property as very low, about 30% of them characterise it as low and only about 15% of them as medium.

The table below shows the results of analysis of how educators perceive the learners' desire to do well in school.

Table 4.6.9 Learners' desire to do well in school.

	Frequency	Percent
Low	8	24.2
Medium	17	51.5
High	8	24.2
Total	33	100.0

The results indicate that about 24% of educators characterise the learners' desire to do well in school as low, about 52% of them characterise it as medium and only about 24% of them as high.

4.2.7 Physics learners in schools and time spent on physics.

Schools with most (20-29) of the learners in physics are at 45.5%, followed by 10 to 19 learners at 39.4% while the lowest numbers 6.1% (less 10 learners) and 9.1% had more than 40 learners.

The number of physics classes in minutes per period and number of physics classes the educators were teaching per week were also analysed. The results showed that about 76% of educators have overall duration of 210 to 300 minutes to teach physics per week while about 24% have more than 300 minutes per week to teach physics. Most educators, at 76%, had 3 or more physics classes to teach per week, about 15% had two classes while only 9% had one physics classes to teach every week.

It was also discovered that most educators (39.4%) usually spend about 90 to 180 minutes, 30.3% needed about 240 to 300 minutes, 15.2% need 90 minutes or less, 9.1% spend 180 to 240 minutes and Only 6.1% spends more than 300 minutes per week to prepare a lesson to teach a physics class. All educators believe they need and use a textbook as a basis and guideline for instruction to prepare for their physics class lesson.

4.2.8 Use of physics textbooks for and by learners

They also believe that they need to ensure that every learner must have his or her own textbook to learn. All educators again often require their learners to read about physics theory from their textbooks while following tables show results of how often they do require their learners to do certain activities or tasks.

The table below shows the results the frequency on how often learners do problems or exercises from their textbooks.

Table 4.7.1 Do problems or exercises from their textbooks.

	Frequency	Percent
Some lessons	20	60.6
About half the lessons	12	36.4
Every or almost every lesson	1	3.0
Total	33	100.0

The results indicate that about 61% of learners do problems or exercises from their textbooks in some lessons, about 30% of them in about half the lessons and only about 3% of them in every or almost every lesson.

The table below shows the results the frequency on how often learners read the textbook examples of how to do problems or exercises.

Table 4.7.2 Read the textbook examples of how to do problems or exercises.

	Frequency	Percent
Never	13	39.4
Some lessons	20	60.6
Total	33	100.0

The results indicate that about 61% of learners read the textbook examples of how to do problems or exercises in some lessons, and about 39% of them never read the textbook examples of how to do problems or exercises.

4.2.9 Number of physics lessons, and the percentage of time the learners do spend on each of the activities.

The results below indicate in a typical week of physics lessons, the percentage of time the learners do spend on each of the activities. About 0 to 9 % is completely spent on the following:

- Reviewing and summarizing what has been taught for the whole class,
- Oral or written tests or quizzes,
- Classroom management tasks not related to the lesson's content/purpose (e.g., interruptions and keeping order),
- Other activities.

Table below shows varying percentage of time spent on teaching new material to the whole class and where learners are prompted to spend on certain, listed activities:

Table 4.8.1 Teaching new material to the whole class

	Frequency	Percent
From 30 – 39	14	42.4
From 40 – 49	19	57.6
Total	33	100.0

The results indicate that about 42% of 30 – 39 minutes were spent on teaching new material to the whole class and where learners are prompted to spend on certain, listed activities, and about 58% of 40 – 49 minutes were spent on this teaching.

Table below shows varying percentage of time spent on learners working problems on their own or with other learners:

Table 4.8.2 Learners working problems on their own or with other learners.

	Frequency	Percent
From 10 - 19	17	51.5
From 20 - 29	16	48.5
Total	33	100.0

The results indicate that about 52% of 10 – 19 minutes were spent on learners working problems on their own or with other learners, and about 48% from 20 – 29 minutes were spent on learners working problems on their own or with other learners.

Table below shows varying percentage on time spent on reviewing homework and where learners are prompted to spend on certain, listed activities:

Table 4.8.3 Reviewing homework

	Frequency	Percent
From 0 - 9	32	97.0
From 10 - 19	1	3.0
Total	33	100.0

The results indicate that about 97% of 0 – 9 minutes were spent on reviewing homework, and about 3% from 10 – 19 minutes were spent on reviewing homework.

Table below shows varying percentage on time spent on re-teaching and clarifying content/procedures for the whole class and where learners are prompted to spend on certain, listed activities:

Table 4.8.4 Re-teaching and clarifying content/procedures for the whole class.

	Frequency	Percent
From 0 - 9	1	3.0
From 10 - 19	32	97.0

Total	33	100.0
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The results indicate that about 3% of 0 – 9 minutes were spent on re-teaching and clarifying content/procedures for the whole class a, and about 97% from 10 – 19 minutes were spent on re-teaching and clarifying content/procedures for the whole class.

4.2.10 The rate of asking learners on the given physics aspects

Asked on how often do they usually ask the learners to watch the educator demonstrate an experiment or investigation:

Table 4.9.1 Watch me demonstrate an experiment or investigation.

	Frequency	Percent
Some lessons	33	100.0

The results shows that the educator uses 100% in some lessons to ask the learners to watch him/her demonstrate an experiment or investigation.

Asked on how often do they usually ask the learners to conduct experiments or investigations.

Table 4.9.2 Conduct experiments or investigations

	Frequency	Percent
About half the lessons	33	100.0

The results shows that the educator uses 100% in about half the lessons to ask the learners to conduct experiments or investigations.

Asked on how often do they usually ask the learners to use laws and formulas of physics to solve routine problems.

Table 4.9.3 Use laws and formulas of physics to solve routine problems.

	Frequency	Percent
Every or almost every lesson	33	100.0

The results shows that the educator uses 100% in every or almost every lesson to ask the learners to use laws and formulas of physics to solve routine problems.

Asked on how often do they usually ask the learners to give explanations about something they are studying.

Table 4.9.4 Give explanations about something they are studying.

	Frequency	Percent
About half the lessons	33	100.0

The results shows that the educator uses 100% in about half the lessons to give explanations about something they are studying.

Asked on how often do they usually ask the learners to relate what they are learning in physics to their daily lives.

Table 4.9.5 Relate what they are learning in physics to their daily lives.

	Frequency	Percent
Every or almost every lesson	33	100.0

The results shows that the educator uses 100% in every or almost every lesson to relate what they are learning in physics to their daily lives.

Asked on how often do they usually ask the learners to have learners memorize formulas and procedures.

Table 4.9.6 Have learners memorize formulas and procedures.

	Frequency	Percent
Never	26	78.8
Some lessons	7	21.2
Total	33	100.0

The results shows that the educator uses 79% never ask the learners to have learners memorize formulas and procedures while only about 21% in some lessons ask learners to memorize formulas and procedures.

Asked on how often do they usually ask the learners to read their textbooks or other resource materials.

Table 4.9.7 Read their textbooks or other resource materials.

	Frequency	Percent
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Valid	Some lessons	33	100.0
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The results shows that the educator uses 100% in some lessons to read their textbooks or other resource materials.

4.2.11 Educators' views on factors limiting teaching the physics class.

On how in their view as to what extent do the following aspects limit how effectively they teach the physics class, the results of the educators' responses were as follows:

Asked on how often do they usually deal with the learners with different academic abilities.

Table 4.10.1 Learners with different academic abilities

	Frequency	Percent
A little	33	100.0

The results show that 100% of the educators deal a little with the learners with different academic abilities.

Asked on how often do they usually deal with the learners who come from a wide range of backgrounds (e.g., economic, language).

Table 4.10.2 Learners who come from a wide range of backgrounds (e.g., economic, language)

	Frequency	Percent
Some	9	27.3
A little	24	72.7
Total	33	100.0

The results show that about 73% of the educators deal a little with the learners who come from a wide range of backgrounds (e.g., economic, language) and only about 27% of them deal with some.

Asked on how often do they usually deal with the learners with special needs (e.g., hearing, vision, speech impairment, physical or learning disabilities).

Table 4.10.3 Learners with special needs (e.g., hearing, vision, speech impairment, physical or learning disabilities)

	Frequency	Percent
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Not at all	33	100.0
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The results show that 100% of the educators do not deal at all with Learners with special needs (e.g., hearing, vision, speech impairment, physical or learning disabilities).

Asked on how often do they usually deal with uninterested learners.

Table 4.10.4 Uninterested learners

	Frequency	Percent
A lot	6	18.2
Some	10	30.3
A little	16	48.5
Not at all	1	3.0
Total	33	100.0

The results show that about 49% of the educators deal a little with uninterested learners, about 18% of them a lot, about 30% with some, and only 3% of them do not at all.

Asked on how often do they usually deal with the disruptive learners.

Table 4.10.5 Disruptive learners

	Frequency	Percent
A lot	6	18.2
Some	10	30.3
A little	16	48.5
Not at all	1	3.0
Total	33	100.0

The results show that about 49% of the educators deal a little with disruptive learners, about 18% of them a lot, about 30% with some, and only 3% of them do not at all.

Asked on how often do they usually deal with high student/teacher ratio.

Table 4.10.6 High student/teacher ratio

	Frequency	Percent
Some	6	18.2
A little	27	81.8
Total	33	100.0

The results show that about 82% of the educators deal a little with high student/teacher ratio and about 18% of them deal with some.

4.2.12 Learners' use of calculators in a physics class

The tables indicate results of responses of educators on how often their learners in the physics class do use calculators in their physics lessons in the given aspects:

Asked on how often do they usually ask the learners to do scientific procedures or experiments.

Table 4.11.1 Doing scientific procedures or experiments.

	Frequency	Percent
Some lessons	9	27.3
About half the lessons	2	6.1
Every or almost every lesson	22	66.7
Total	33	100.0

The results shows that about 67% of educators ask the learners in every or almost every lesson to do scientific procedures or experiments, about 27% of them in some lessons while only about 6% of them in about the lessons.

Asked on how often do they usually ask the learners to do modelling and simulations.

Table 4.11.2 Modelling and simulations

	Frequency	Percent
Some lessons	33	100.0

The results shows that 100% of educators ask the learners in some lessons to do modelling and simulations.

Asked on how often do they usually ask the learners to solve equations.

Table 4.11.3 Solving equations.

	Frequency	Percent
Every or almost every lesson	33	100.0

The results shows that 100% of educators ask the learners in every and almost lesson to solve equations.

Asked on how often do they usually ask the learners on processing and analysing data.

Table 4.11.4 Processing and analysing data.

	Frequency	Percent
Some lessons	8	24.2
About half the lessons	10	30.3
Every or almost every lesson	15	45.5
Total	33	100.0

The results shows that about 46% of educators ask the learners in every and almost every lesson on processing and analysing data, about 24% of them in some lessons while about 30% of them ask learners in about half the lessons.

4.2.13 Learners' use of algebraic knowledge or skills in their physics lessons

The educators were also asked as to how often their learners in the physics class use algebraic knowledge or skills in their physics lessons for the following activities:

Asked on how often do they usually ask the learners on doing scientific procedures or experiments.

Table 4.12.1 Doing scientific procedures or experiments.

	Frequency	Percent
Every or almost every lesson	33	100.0

The results shows that 100% of the educators ask the learners in every and almost every lesson on doing scientific procedures or experiments.

Asked on how often do they usually ask the learners on processing and analyzing data.

Table 4.12.2 Processing and analyzing data.

	Frequency	Percent
About half the lessons	33	100.0

The results shows that 100% of the educators ask the learners in about half the lessons on processing and analysing data.

Asked on how often do they usually ask the learners on plotting a graph.

Table 4.12.3 Plotting a graph.

	Frequency	Percent
About half the lessons	33	100.0

The results shows that 100% of the educators ask the learners in about half the lessons on plotting a graph.

Asked on how often do they usually ask the learners on the interpretation of graph and or results.

Table 4.12.4 interpretation of graph and or results

	Frequency	Percent
Every or almost every lesson	33	100.0

The results shows that 100% of the educators ask the learners in every and almost every lesson on the interpretation of graph and or results.

Asked on how often do they usually ask the learners on solving equations.

Table 4.12.5 Solving equations.

	Frequency	Percent
About half the lessons	22	66.7
Every or almost every lesson	11	33.3
Total	33	100.0

The results shows that about 33% of the educators ask the learners in every and almost every lesson on solving equations, and about 67% of them ask in about half the lessons.

4.2.14 Named kinds of physics homework to the physics class

The results below show how often do educators assign the named kinds of physics homework to the physics class:

Asked on how often do they usually ask the learners homework on doing problem/question sets.

Table 4.13.1 Doing problem/question sets.

	Frequency	Percent
Always or almost always	33	100.0

The results shows that 100% of educators ask the learners always and almost always homework on doing problem/question sets.

Asked on how often do they usually ask the learners on reading their textbooks.

Table 4.13.2 Reading the textbook.

	Frequency	Percent
Sometimes	33	100.0

The results shows that 100% of educators ask the learners sometimes homework on reading the textbook.

Asked on how often do they usually ask the learners on memorizing formulas and procedures.

Table 4.13.3 Memorizing formulas and procedures

	Frequency	Percent
Never or almost never	9	27.3
Sometimes	24	72.7
Total	33	100.0

The results shows that about 73% of educators ask the learners sometimes on memorizing formulas and procedures, and only about 27% of them never or almost never ask the learners.

Asked on how often do they usually ask the learners on gathering, analysing, and reporting data.

Table 4.13.4 Gathering, analysing, and reporting data.

	Frequency	Percent	
Sometimes	25	75.8	
Always or almost always	8	24.2	
Total	33	100.0	

The results shows that about 76% of educators ask the learners sometimes on gathering, analysing, and reporting data, and about 24% of them always and almost always ask.

Asked on how often do they usually ask the learners on finding one or more applications of the content covered.

Table 4.13.5 Finding one or more applications of the content covered.

	Frequency	Percent
Always or almost always	33	100.0

The results shows that 100% of educators ask the learners always and almost always homework on finding one or more applications of the content covered.

Asked on how often do they usually ask the learners on working on projects.

Table 4.13.6 Working on projects.

	Frequency	Percent
Sometimes	20	60.6
Always or almost always	13	39.4
Total	33	100.0

The results shows that about 39% of educators ask the learners always and almost always homework on working on projects and only about 61% of them ask sometimes.

4.2.15 Emphasis on the mentioned sources to monitor learners' progress in physics.

Educators had to also respond as to how much emphasis do they place on the mentioned sources to monitor learners' progress in physics and the results were as follows:

Asked on how much emphasis do they usually put to monitor the learners' progress in physics with classroom tests (e.g., teacher-made, or textbook tests).

Table 4.14.1 Classroom tests (e.g., teacher-made, or textbook tests)

	Frequency	Percent
Major emphasis	33	100.0

The results shows that 100% of the educators place major emphasis on classroom tests (e.g., teacher-made, or textbook tests) to monitor learners' progress in physics.

Asked on how much emphasis do they usually put to monitor the learners' progress in physics with informal assessment.

Table 4.14.2 Informal assessment

	Frequency	Percent
Little emphasis	13	39.4
Some emphasis	20	60.6
Total	33	100.0

The results shows that about 61% of the educators place some emphasis on informal assessment to monitor learners' progress in physics, and about 39% of them place little emphasis.

Asked on how much emphasis do they usually put to monitor the learners' progress in physics with other tests.

Table 4.14.3 Other tests

	Frequency	Percent
Little emphasis	20	60.6
Some emphasis	9	27.3
Major emphasis	4	12.1

Total	33	100.0
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The results shows that about 61% of the educators place little emphasis on other tests to monitor learners' progress in physics, about 27% of them put some emphasis while about 12% place major emphasis.

4.2.16 Listed types of physics questions in their learners' physics class tests and or examination

On how often educators include the listed types of physics questions in their learners' physics class tests and or examination, the results were as below:

Asked on how often do they usually include questions based on knowing facts and concepts in their learners' physics class tests and or examination.

Table 4.15.1 Questions based on knowing facts and concepts.

	Frequency	Percent
Sometimes	11	33.3
Always or almost always	22	66.7
Total	33	100.0

The results shows that about 67% of the educators sometimes usually include questions based on knowing facts and concepts in their learners' physics class tests and or examination, about 33% of them always or almost always include questions based on knowing facts and concepts.

Asked on how often do they usually include questions based on the application of knowledge and understanding in their learners' physics class tests and or examination.

Table 4.15.2 Questions based on the application of knowledge and understanding.

	Frequency	Percent
Always or almost always	33	100.0

The results shows that 100% of the educators always and almost always include questions based on the application of knowledge and understanding in their learners' physics class tests and or examination.

Asked on how often do they usually include questions involving developing hypotheses and designing scientific investigations in their learners' physics class tests and or examination.

Table 4.15.3 Questions involving developing hypotheses and designing scientific investigations.

	Frequency	Percent
Sometimes	33	100.0

The results shows that 100% of the educators sometimes include questions involving developing hypotheses and designing scientific investigations in their learners' physics class tests and or examination.

Asked on how often do they usually include questions requiring explanations or justifications in their learners' physics class tests and or examination.

Table 4.15.4 Questions requiring explanations or justifications.

	Frequency	Percent
Always or almost always	33	100.0

The results shows that 100% of the educators sometimes include questions requiring explanations or justifications in their learners' physics class tests and or examination.

4.2.17 Constructed response vs objective item formats and practical examination or laboratory problems.

All educators (100%) responded that they typically use about half constructed response and half objective item formats in their physics tests and examinations. They (100%) also often include a practical examination or laboratory problems in their physics tests and examinations.

4.2.18 Time spent per week outside the normal school day.

The tables below show the results of approximate number of hours per week the educators normally spend on each of the listed activities outside the formal school day:

Asked on how much time per week outside the formal school day do they usually spend on preparing or grading student tests or exams.

Table 4.16.1 Preparing or grading student tests or exams.

	Frequency	Percent
More than 4 hours	33	100.0

The results shows that 100% of the educators spend more than four (4) hours per week outside the formal school day do they usually spend on preparing or grading student tests or exams.

Asked on how much time per week outside the formal school day do they usually spend on reading and grading other student work.

Table 4.16.2 Reading and grading other student work.

	Frequency	Percent
More than 4 hours	33	100.0

The results shows that 100% of the educators usually spend more than four (4) hours per week outside the formal school day on reading and grading other student work.

Asked on how much time per week outside the formal school day do they usually spend on planning lessons by themselves.

Table 4.16.3 Planning lessons by yourself.

	Frequency	Percent
3 - 4 hours	33	100.0

The results shows that 100% of the educators usually spend three (3) to four (4) hours per week outside the formal school day on planning lessons by yourself.

Asked on how much time per week outside the formal school day do they usually spend on meeting with learners outside of classroom time (e.g., tutoring, guidance).

Table 4.16.4 Meeting with learners outside of classroom time (e.g., tutoring, guidance)

	Frequency	Percent
1 - 2 hours	33	100.0

The results shows that 100% of the educators usually spend one (1) to two (2) hours per week outside the formal school day).

Asked on how much time per week outside the formal school day do they usually spend on meeting with parents.

Table 4.16.5 Meeting with parents.

	Frequency	Percent
None	18	54.5
Less than 1 hour	15	45.5
Total	33	100.0

The results shows that about 46% of the educators usually spend less than (1) hour per week outside the formal school day on meeting with parents and only about 54% usually do not have meetings with parents.

Asked on how much time per week outside the formal school day do they usually spend on professional reading and development activity (e.g., seminars, conferences, etc).

Table 4.16.6 Professional reading and development activity (e.g., seminars, conferences, etc)

	Frequency	Percent
3 - 4 hours	17	51.5
More than 4 hours	16	48.5
Total	33	100.0

The results shows that about 49% of the educators usually spend more than four (4) hours per week outside the formal school day do on professional reading and development activity (e.g., seminars, conferences, etc) and about 51% of them usually spend three (3) to four (4) hours.

Asked on how much time per week outside the formal school day do they usually spend on keeping learners' records up to date.

Table 4.16.7 Keeping learners' records up to date.

	Frequency	Percent
1 - 2 hours	25	75.8
3 - 4 hours	8	24.2
Total	33	100.0

The results shows that about 76% of the educators usually spend one (1) to two (2) hours per week outside the formal school day on keeping learners' records up to date, and about 24% of them usually spend three (3) to four (4) hours.

Asked on how much time per week outside the formal school day do they usually spend on administrative tasks including staff meetings (e.g., photocopying, displaying learners' work).

Table 4.16.8 Administrative tasks including staff meetings (e.g., photocopying, displaying learners' work).

	Frequency	Percent
Less than 1 hour	33	100.0

The results shows that 100% of the educators spend less than (1) hour per week outside the formal school day on administrative tasks including staff meetings (e.g., photocopying, displaying learners' work).

Asked on how much time per week outside the formal school day do they usually spend on other matters.

Table 4.16.9 Other

	Frequency	Percent
1 - 2 hours	25	75.8
3 - 4 hours	8	24.2
Total	33	100.0

The results shows that about 76% of the educators usually spend one (1) to two (2) hours per week outside the formal school day on other matters, and about 24% of them usually spend three (3) to four (4) hours.

4.2.19 Approximate time spent on teaching inside and outside school.

All educators further shown that they approximately spend normally about more than four hours altogether per week on teaching activities, this includes time spent in and outside the school.

4.2.20 How important it is to be good in science at school for learners based on the different aspects.

The results below further indicated how educators believe that it is important to be good at science at school for learners based on the aspects given per table below:

Asked on how important it is do they think to ask the learners to remember formulas and procedures.

Table 4.17.1 Remember formulas and procedures.

	Frequency	Percent
Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to remember formulas and procedures.

Asked on how important it is do they think to ask the learners to think in a sequential and procedural manner.

Table 4.17.2 Think in a sequential and procedural manner.

	Frequency	Percent
Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to think in a sequential and procedural manner.

Asked on how important it is do they think to ask the learners to understand science concepts, principles, and strategies.

Table 4.17.3 Understand science concepts, principles, and strategies.

	Frequency	Percent
Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to understand science concepts, principles, and strategies.

Asked on how important it is do they think to ask the learners to be able to think creatively.

Table 4.17.4 Be able to think creatively.

	Frequency	Percent
Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to be able to think creatively.

Asked on how important it is do they think to ask the learners to understand how science is used in the real world.

Table 4.17.5 Understand how science is used in the real world.

	Frequency	Percent
3: Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to understand how science is used in the real world.

Asked on how important it is do they think to ask the learners to be able to provide reasons to support their conclusions.

Table 4.17.6 Be able to provide reasons to support their conclusions.

	Frequency	Percent
3: Very important	33	100.0

The results shows that 100% of the educators believe it is very important to ask the learners to be able to provide reasons to support their conclusions.

4.2.21 Educators' influence on certain aspects

The tables below depict the results of how much influence do they have on each of the given aspects:

Asked on how influence do they usually have on subject matter to be taught.

Table 4.18.1 Subject matter to be taught.

	Frequency	Percent
A lot	33	100.0

The results shows that 100% of the educators believe they have a lot of influence on the subject matter to be taught.

Asked on how influence do they usually have on the specific textbooks to be used.

Table 4.18.2 Specific textbooks to be used.

	Frequency	Percent
None	33	100.0

The results shows that 100% of the educators believe they have no influence on the specific textbooks to be used.

Asked on how influence do they usually have on the amount of money to be spent on supplies.

Table 4.18.3 The amount of money to be spent on supplies.

	Frequency	Percent
None	24	72.7
Little	3	9.1
Some	6	18.2
Total	33	100.0

The results shows that about 73% of the educators believe they have no influence on the amount of money to be spent on supplies, about 9% of them think they have little influence while about 18% of them think they have some influence.

Asked on how influence do they usually have on what supplies are purchased.

Table 4.18.4 What supplies are purchased.

	Frequency	Percent
Some	23	69.7
A lot	10	30.3
Total	33	100.0

The results shows that about 30% of the educators believe they have a lot of influence on what supplies are purchased, while about 70% of them have some influence.

4.2.22 Meetings with other educators in their subject area

The educators were also asked about how often they do have meetings with other educators in their subject area to discuss and plan curriculum or teaching approaches, the results were as follows:

Asked on how often do they usually have meetings with other same subject area educators.

Table 4.19 Frequency of meeting with other same subject area educators

	Frequency	Percent
once or twice a year	16	48.5
every other month	17	51.5
Total	33	100.0

The results shows that about 49% of the educators said they meet once or twice a year with other same subject area educators to discuss and plan curriculum or teaching approaches, and about 51% of them said they meet with other same subject area educators every month.

4.2.23 Educators' extent to agree or disagree with principles.

As to what extent do they agree or not with the mentioned statements, the results of the educators' responses are given in the tables below:

Asked on the extent to which they agree or disagree that science is primarily an abstract subject.

Table 4.20.1 Science is primarily an abstract subject.

	Frequency	Percent
Agree	33	100.0

The results shows that 100% of the educators do agree that science is primarily an abstract subject.

Asked on the extent to which they agree or disagree that science is primarily a formal way of representing the real world.

Table 4.20.2 Science is primarily a formal way of representing the real world.

	Frequency	Percent
Agree	24	72.7
Strongly agree	9	27.3
Total	33	100.0

The results shows that about 73% of the educators do agree that science is primarily a formal way of representing the real world while about 27% of them strongly agree.

Asked on the extent to which they agree or disagree that science is primarily a practical and structured guide for addressing real situations.

Table 4.20.3 Science is primarily a practical and structured guide for addressing real situations.

	Frequency	Percent
Strongly agree	33	100.0

The results shows that 100% of the educators strongly agree that science is primarily a practical and structured guide for addressing real situations.

Asked on the extent to which they agree or disagree that some learners have a natural talent for science and others do not.

Table 4.20.4 Some learners have a natural talent for science and others do not.

	Frequency	Percent
Agree	33	100.0

The results shows that 100% of the educators do agree that some learners have a natural talent for science and others do not.

Asked on the extent to which they agree or disagree that it is important for teachers to give learners prescriptive and sequential directions for doing science experiments.

Table 4.20.5 It is important for teachers to give learners prescriptive and sequential directions for doing science experiments.

	Frequency	Percent
Strongly agree	33	100.0

The results shows that 100% of the educators strongly agree that it is important for teachers to give learners prescriptive and sequential directions for doing science experiments.

Asked on the extent to which they agree or disagree that focusing on rules is a bad idea. It gives learners the impression that the sciences (physics, chemistry, biology, and earth science) are a set of procedures to be memorized.

Table 4.20.6 Focusing on rules is a bad idea. It gives learners the impression that the sciences (physics, chemistry, biology, and earth science) are a set of procedures to be memorized.

	Frequency	Percent
Disagree	8	24.2
Agree	10	30.3
Strongly agree	15	45.5
Total	33	100.0

The results shows that about 30% of the educators do agree that focusing on rules is a bad idea. It gives learners the impression that the sciences (physics, chemistry,

biology, and earth science) are a set of procedures to be memorized, about 46% of them strongly agree while about 24% of them disagree.

Asked on the extent to which they agree or disagree that if learners get into debates in class about ideas or procedures covering the sciences, it can harm their learning.

Table 4.20.7 If learners get into debates in class about ideas or procedures covering the sciences, it can harm their learning.

	Frequency	Percent
Strongly disagree	33	100.0

The results shows that 100% of the educators strongly agree that if learners get into debates in class about ideas or procedures covering the sciences, it can harm their learning.

Asked on the extent to which they agree or disagree that learners see a science task as the same task when it is represented in two different ways picture, concrete material, symbol set, etc).

Table 4.20.8 Learners see a science task as the same task when it is represented in two different ways picture, concrete material, symbol set, etc)

	Frequency	Percent
Agree	33	100.0

The results shows that 100% of the educators do agree that learners see a science task as the same task when it is represented in two different ways picture, concrete material, symbol set, etc).

Asked on the extent to which they agree or disagree that a liking for and understanding of learners are essential for teaching science.

Table 4.20.9 A liking for and understanding of learners are essential for teaching science.

	Frequency	Percent
Agree	22	66.7
Strongly agree	11	33.3
Total	33	100.0

The results shows that about 67% of the educators agree that a liking for and understanding of learners are essential for teaching science while about 33% of them strongly agree.

4.2.24 Educators' preparedness and confidence to teach certain specific concepts/topics.

The results further show that all educators (100%) are very well prepared and have confidence to teach the following topics:

- Mechanics
- Kinematics
- Measurements and Dimensional analysis

4.2.25 Educators' highest level of formal education, teacher training certificate or qualification, pre-service years, etc.

The tables below indicate the highest level of formal education they have completed, if ever they do have teacher training certificate or qualification, the number of years they had in pre-service, and if ever they did pre-service teacher including teaching practice, whether they started this training at high school, the FET Phase.

Asked what highest qualification do they possess:

Table 4.21.1 The highest level of formal education completed.

	Frequency	Percent
Diploma	4	12.1
Bachelor's degree or equivalent	15	45.5
Honours or B. Tech.	11	33.3
Master's degree	3	9.1
Total	33	100.0

The results shows that the majority (about 46%) of educators have a bachelor's degree or equivalent, about 33% of them have either Honours or BTech degree, about 12% of them have Diploma and about 9% of them have Masters' degree.

Asked if they do possess a teacher training certificate/qualification, responses were as follows.

Table 4.21.2 Teacher training certificate/qualification

	Frequency	Percent
Yes	24	72.7
No	9	27.3
Total	33	100.0

The results shows that about 73% of the educator do have a teacher training certificate/qualification, and only about 27% of them do not have.

Asked on the number of years of pre-service teacher training they had:

Table 4.21.3 Years of pre-service teacher training had

	Frequency	Percent
Zero years	9	27.3
1 Year	1	3.0
2 Years	2	6.1
3 Years	4	12.1
4 Years	15	45.5
More than 4 years	2	6.1
Total	33	100.0

The results shows that majority (about 46%) of the educators have four (4) years of pre-service teacher training, about 27% of them do not have, 12% have three (3) years, about 6% have two years and more than 4 years, and about 3% have one (1) year.

Asked if their pre-service teacher training (teaching practice) started in high school (FET Phase):

Table 4.21.4 Pre-service teacher training (teaching practice) started in high school (FET Phase)?

	Frequency	Percent
Yes	22	66.7
No	11	33.3
Total	33	100.0

The results shows that about 67% of the educators do have their pre-service teacher training (teaching practice) started in high school (FET Phase), and about 33% of them did not.

4.2.26 Subject specialisations (major subjects) during pre-service science teacher training

The subject specialisations (major subjects) during pre-service science teacher training gave the following results:

Asked if they have physics as major subject during pre-service science teacher training:

Table 4.22.1 Physics

	Frequency	Percent
Yes	14	42.4
No	19	57.6
Total	33	100.0

The results shows that about 42% of the educators did have physics as major subject during pre-service science teacher training, and about 58% did not have it.

Asked if they have Chemistry as major subject during pre-service science teacher training.

Table 4.22.2 Chemistry

	Frequency	Percent
Yes	20	60.6
No	13	39.4
Total	33	100.0

The results shows that about 61% of the educators did have Chemistry as major subject during pre-service science teacher training, and about 39% did not have it.

Asked if they have Physical Sciences as major subject during pre-service science teacher training.

Table 4.22.3 Physical Sciences

	Frequency	Percent
Yes	7	21.2
No	26	78.8
Total	33	100.0

The results shows that about 21% of the educators did have Physical Sciences as major subject during pre-service science teacher training, and about 79% did not have it.

Asked if they have Mathematics as major subject during pre-service science teacher training.

Table 4.22.4 Mathematics

		Frequency	Percent
Valid	Yes	27	81.8
	No	6	18.2
	Total	33	100.0

The results shows that about 82% of the educators did have Mathematics as major subject during pre-service science teacher training, and about 18% did not have it.

Asked if they have physics as major subject during pre-service science teacher training.

Table 4.22.5 Physical Science Methodology

		Frequency	Percent
	0	1	3.0
	Yes	13	39.4
	No	19	57.6
	Total	33	100.0

The results shows that about 39% of the educators did have Physical Science Methodology as major subject during pre-service science teacher training, and about 61% did not have it.

Asked if they have physics as major subject during pre-service science teacher training.

Table 4.22.6 Mathematics Methodology

		Frequency	Percent
	Yes	9	27.3
	No	24	72.7
	Total	33	100.0

The results shows that about 27% of the educators did have Mathematics Methodology as major subject during pre-service science teacher training, and about 73% did not have it.

Asked if they have Education as major subject during pre-service science teacher training.

Table 4.22.7 Education

	Frequency	Percent
Yes	24	72.7
No	9	27.3
Total	33	100.0

The results shows that about 73% of the educators did have Education as major subject during pre-service science teacher training, and about 27% did not have it.

4.2.27 Questions on the learning aspects

The educators were further asked if:

- Learning and problem solving in kinematics graphs do require mathematics knowledge and skills (algebra)
- Learners can relate terminologies and symbols in kinematics with the variable and terms in algebra/mathematics.

The results of their responses are tabulated below.

Asked if learning and problem solving in kinematics graphs do require mathematics knowledge and skills.

Table 4.23.1 Do learning and problem solving in kinematics graphs require mathematics knowledge and skills.

	Frequency	Percent
Yes	18	54.5
No	7	21.2
Somehow	8	24.2
Total	33	100.0

The results shows that about 55% of the educators agree that learning and problem solving in kinematics graphs require mathematics knowledge and skills, about 21% did not agree and about 24% said somehow.

Asked if learners can relate terminologies or symbols in kinematics with variables in algebra/mathematics:

Table 4.23.2 Are learners able to relate terminologies or symbols in kinematics with variables in algebra/mathematics?

	Frequency	Percent
No	23	69.7
Somehow	10	30.3
Total	33	100.0

The results shows that about 70% of the educators did not agree that learners are able to relate terminologies or symbols in kinematics with variables in algebra/mathematics and about 30% said somehow.

4.2.28 Questions on the teaching of kinematics aspects

In their teaching of kinematics to their learners in class, educators indicated as to how often do they usually emphasize and ask their learner to do the listed principles or concepts, the results showed that they did that in each or almost in every lesson of these principles or concepts:

- Describing Motion with Words
- Describing Motion with Diagrams
- The Meaning of Shape for a p-t Graph
- Meaning of Slope for a p-t Graph
- Determining the Slope on a p-t Graph
- Meaning of Shape for a v-t Graph
- Meaning of Slope for a v-t Graph
- Relating the Shape to the Motion
- Determining the Slope on a v-t Graph
- Determining the Area on a v-t Graph
- Construct an informative diagram of the physical situation.
- Identify and list the given information in variable form.
- Identify and list the unknown information in variable form.
- Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information.
- Check the answer to ensure that it is reasonable and mathematically correct.

When asked about how often in teaching kinematics to the learners they usually do emphasize and ask their learners to identify and list the unknown information in variable form, the results shows that majority of educators (97%) do that while only 3% do not.

4.2.29 Educators' experience on learners' performance on the above principles or aspects

In general, and according to the educators' experience, there were different views as to how the learners perform in the above principles or concepts. The results of responses of the educators were tabulated as below:

Asked on how learners perform on "Describing Motion with Words":

Table 4.24.1 Describing Motion with Words

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on "Describing Motion with Words" is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on Describing 'Motion with Diagrams':

Table 4.24.2 Describing Motion with Diagrams

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on "Describing Motion with Diagrams" is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on "The Meaning of Shape for a s-t Graph":

Table 4.24.3 The Meaning of Shape for a s-t Graph

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “The Meaning of Shape for a s-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Meaning of Slope for a s-t Graph”:

Table 4.24.4 Meaning of Slope for a s-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Meaning of Slope for a s-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Determining the Slope on a s-t Graph”:

Table 4.24.5 Determining the Slope on a s-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Determining the Slope on a s-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Meaning of Shape for a v-t Graph”:

Table 4.24.6 Meaning of Shape for a v-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Meaning of Shape for a v-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Meaning of Slope for a v-t Graph”:

Table 4.24.7 Meaning of Slope for a v-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Meaning of Slope for a v-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Relating the Shape to the Motion”:

Table 4.24.8 Relating the Shape to the Motion

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Relating the Shape to the Motion” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Determining the Slope on a v-t Graph”:

Table 4.24.9 Determining the Slope on a v-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Determining the Slope on a v-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Determining the Area on a v-t Graph”:

Table 4.24.10 Determining the Area on a v-t Graph.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Determining the Area on a v-t Graph” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Constructing an informative diagram of the physical situation”:

Table 4.24.11 Construct an informative diagram of the physical situation.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Constructing an informative diagram of the physical situation” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Identifying and listing the given information in variable form”:

Table 4.24.12 Identify and list the given information in variable form.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Identifying and listing the given information in variable form” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Identifying and listing the unknown information in variable form”:

Table 4.24.13 Identify and list the unknown information in variable form.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Identifying and listing the unknown information in variable form” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Identifying and listing the equation that will be used to determine unknown information from known information”:

Table 4.24.14 Identify and list the equation that will be used to determine unknown information from known information.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Identifying and listing the equation that will be used to determine unknown information from known information” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information”:

Table 4.24.15 Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

Asked on how learners perform on “checking answer to ensure that it is reasonable and mathematically correct”:

Table 4.24.16 Check your answer to ensure that it is reasonable and mathematically correct.

	Frequency	Percent
Poor	16	48.5
Below average	7	21.2
Average	8	24.2
Good	2	6.1
Total	33	100.0

The results shows that about 49% of the educators said performance on “checking answer to ensure that it is reasonable and mathematically correct” is poor, about 24% said it is average, about 21% said it is below average and about 6% said it is good.

4.3 Quantitative analysis of data – Learners’ questionnaire

4.3.1 Demographics

The results indicate that about 77% were under the age of 18, about 16% were 18 years old and about 7% were above 18 years. Of these, 63% were male while about 37% were females. About 98% of the participants were from rural schools and only about 2% were from urban schools. Most learners, about 95% of participants were doing Grade 11 for the first-time while only about 5% were repeating more than once.

4.3.2 Comparison of learners’ performances in algebra (mathematics) and kinematics (physics) graphs

4.3.2.1 Performance in algebra graphs (mathematics)

The graph below gives an indication of the average performances of learners in algebra (mathematics).

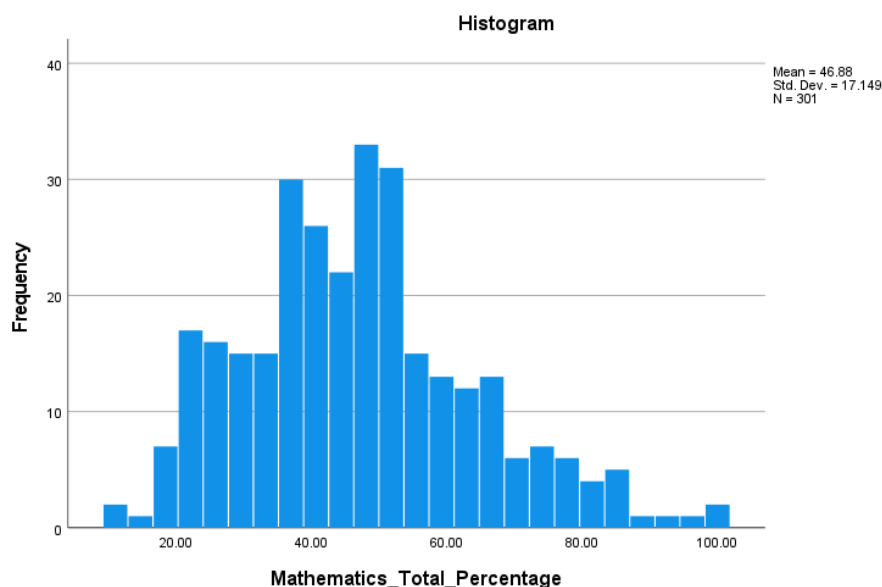


Figure 1: Learner performances in algebra graphs

The results indicate an average performance in algebra graph questions as about 47% and a standard deviation of 17.149. The learners’ performance with lowest percentage per question as about 12% and the highest as about 84%.

4.3.2.2 Performances in kinematics (physics) graphs

The graph below gives an indication of the average performances of learners in kinematics (physics) graphs.

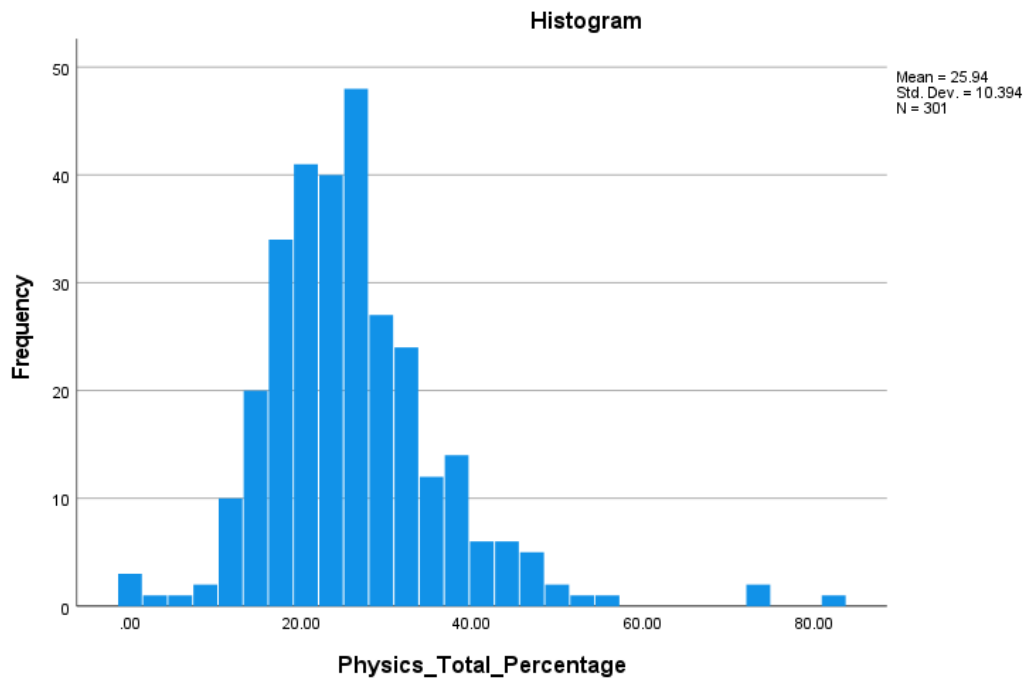


Figure 2: Learner performances in kinematics graphs

The results in learners' performance in kinematics graphs questions shows a Standard Deviation of 10.394 and average of about 26%. Performances per question show that there were two highest of over 70 and several questions with lowest performance of below 10%.

4.3.3 Comparisons of performances per constructs in algebra and kinematics graphs

To determine the perceptions of learners on the performance in construct questions in both graphs in algebra and kinematics, the results in the following tables were obtained.

4.3.3.1 Constructs in algebra graphs

The table below shows the results of the average performance per construct in algebra.

Table 4.25.1 Constructs in algebra graphs

Constructs	Algebra	AVG VALUE
------------	---------	-----------

Integration (s)		
Integration (v)	1.1; 1.2; 7.1; 7.2; 12.1; 13.5	50,39
Differentiation (Gradient) - (a)	2; 5; 6; 8; 9.2; 10.4; 11.1; 11.2; 12.2;	30,20
Differentiation (Gradient) - (v)	13.2; 13.4	48,34
Points (coordinates) on graph	10.1; 10.2; 10.3	67,00
Equations/forms	3; 4.1; 4.2; 4.3	50,42
Constant function values	9.1; 13.1; 13.2; 13.3	55,73

The results show that from six questions on the construct of “integration”, learners obtained an average of about 50%. Their response to nine questions on “differentiation” depicting “acceleration (a)” is 30.2% and the two questions depicting “velocity (v)” is 40.34%; three questions on “points (coordinates) on graph” is 67%; the four questions on “equations/forms” is 50.42% while the four questions on “constant function values” is 55.73%.

4.3.3.2 Constructs in kinematics graphs

The table below shows the results of the average performance per construct in graphs in kinematics.

Table 4.25.2 Constructs in kinematics graphs

Constructs	Kinematics	AVG VALUE
Integration (s)	1; 8.2; 13;18; 19	23,06
Integration (v)	3; 17.1; 17.2	24,70
Differentiation (Gradient) - (a)	2; 4.1; 4.2; 8.3; 9; 10.1; 10.2; 14; 15; 16	20,23
Differentiation (Gradient) - (v)	2; 5; 6.2; 6.4; 7; 9; 12; 14; 15	17,09
Points (coordinates) on graph	6.1; 6.3	50,50
Equations/forms	11; 20.1; 20.2; 20.3	24,75
Constant function values	5; 8.1; 10.2; 14; 15; 16	21,37
Physics knowledge	21; 22.1; 22.2; 22.3	18,19

The results from above table indicate that learners responded to five questions on “integrating the distance (s)”, “integrating velocity (v)”, obtained an average of 23.06% and 24.7% respectively. On the nine questions on “differentiation of acceleration (a)” and another nine questions on “differentiation of velocity (v)”, the learners obtained an

average of 20.23% and 17.09% respectively, on two questions on “points (coordinates) on graph”, the average is 50.5%; on the four questions on “equations/forms”, the average is 24.75%; on the six question on “constant function values”, the average is 21.37% and on the four questions on “physics knowledge”, the average is 18.19%.

4.4 Qualitative analysis of data – Educator’s questionnaire

This section deals with analysis of qualitative data as taken from a focus sample of educators. The data was collected through an open-ended interview question which were shared with this focus group. As according to Creswell et al (2003), sequential design was used as the process of gathering and analysing quantitative data to answer the research questions. The responses of the participants will assist in supporting and accounting for the quantitative data to answer the research questions explicitly.

In terms of the function of an educator, the goal of a lesson, and class tutorial duties, Lund, and Stains (2015), in citing Murray and MacDonald (1997), have reported on some of the intriguing conceptual deviations from components of qualitative analysis. Therefore, the primary goal of this qualitative research will be able to reconstruct the views and meanings of the individuals (educators). This will make it easier for researchers to accept their own subjective input into the process and as a result, act within constructivism framework (Springer, 2010).

Educators believe that teaching of graphs is important as it introduces the learners to world of data of capturing, predictions, comparison, analysis and making sense of information and statistics (interpretation and communication of results). The significance of graphs is simplifying and summarising data from patterns that can be observed and evaluated as visual representations. They also help the learners to deduce and interpret the relationship and proportionality between various variables, independent or dependent variables.

On the aspect of how algebraic graphs relates to kinematics graphs, educators agree that both graphs represent two variables (one dependent and the other independent/fixed) in vertical and horizontal axes. The difference is that axes for algebraic graphs remain the same irrespective of the equation/function but in kinematics graphs, the variables depend on the type of equation. The variables and

properties give the same information but are given specific terminologies in kinematics, e.g., gradient in algebra but average velocity in kinematics.

The terminologies in algebraic graphs are used to define the terminologies in kinematics graphs. Educators echoed that from a velocity-time and displacement-time graphs you will be able to find average acceleration and average velocity respectively by calculating the gradient of each graph. The gradient is therefore defined as the change in velocity and change in displacement over change in time respectively for both graphs, where change in time is the independent variable. The instantaneous velocity for a velocity-time graph by finding a point on the graph and it will be depicted by the value along the vertical axis at a corresponding value along the horizontal axis as at that time. In the displacement-time graph, the instantaneous velocity will be calculated by find the ratio between the coordinates of a point as displacement divided by time.

The educators further agreed that they would integrate algebraic skills in their teaching of kinematics graphs by:

- Demonstration of common basic concepts between the two types of graphs
- Explanation using real life situations in algebraic and kinematics.
- Explanation of terminologies
- Making use of more examples to afford the learners an opportunity to practice these graphs.
- Compilation of questions based on these aspects.
- Learner training on how to tackle questions in algebraic as well as kinematics.

Their argument was basically that to help learners understand kinematics, addressing algebraic rules and trends should be the first step. Thereafter, build on that knowledge and integrate physics concepts. They reiterated that though this is time-consuming as they will now be teaching instead of continuing with using the learners' prior knowledge from their mathematics class.

Problems were also observed for learners to draw and or interpret graphs due to the learners' lack of understanding the meaning of and units used especially in kinematics graphs. Learners also have problems by confusing the plotting of axes for variables. Teaching learners to be able to plot kinematics graphs would also require plotting the

graphs from perspective of coordinates and algebraic equations for comparison with kinematic equations of motion. Linking these principles will re-enforce the problem solving in kinematics graphs. They have difficulties with interpreting kinematics graphs, interpreting its gradients and intercepts in terms of kinematics terminologies. It is evident that learners do not understand algebraic graphs and analysis of these, encounters issues with the interpretation and drawing of motion graphs.

Another teacher stated the following in connection with problems the learners in all the Grades encounter with drawing and interpretation of graphs, I quote:

Problems learners encounter in the drawing of graphs	Problems learners encounter in the interpretation	Intervention strategies
- Overcrowding in these classes - Lack of necessary instruments such as rulers, pencils, and scientific calculators - Lack of supervision and step by step guidance - Learners are not introduced to standardized forms of how these questions are answered. - Learners are now exposed in these classes; due to a lower number of learners, this leads to learners cheating or copying homework because they are pressurized. - Past paper teaching leads to rote learning and learners do not usually understand the concepts	- Language barriers - Introduction of terminology without proper understanding, e.g., independent variable and dependent	• Content training workshops for teachers • Content training sessions for learners so that they can have the aptitude to answer these questions. • Emphasis on the acquisition of basic instruments is crucial.

Asked on how do learners perceive the knowledge and skills of graphs in algebra to solve graphs in kinematics, the educators mentioned that most learners understand algebraic graphs but unable to translate that knowledge or understanding into solving kinematics graphs. Learners also tend to find algebraic graphs as something unpractical and abstract, do not see it as something that can't use in future, real life situations or apply in other concepts. Hence when they are introduced to kinematics graphs, they tend to shut off that prior learning of algebraic graphs.

For learners to be able to translate algebraic graphs prior knowledge skills to kinematics graphs, they expect to be conditioned first, either in algebra class or retaught the concept (require further guidance and support during or) before in a kinematics class. Learners should be familiar and fully understand the quantities before translating them in graphs.

Educators further believe that for learners to understand and know the kinematics graphs concepts, they need to grasp the basics (e.g., dependent, and independent variables, axes and their labels, points on the graphs, and know or understand the terminology and language that is used in kinematics. Their prior knowledge also will assist educators to identify and rectify the common misconceptions they have and be able to extrapolate further on errors that learners tend to make in kinematics. Giving learners constant feedback, giving of multiple presentations that include diagrams, graphs, mathematics equations, etc., will assist to identify their weaknesses and strengths and helps them to improve their understanding of kinematics graphs concepts.

Another educator indicated that the following are the skills physics educators require to infuse in their teaching of kinematics:

- Scaffolding
- Study skills and study methods specific to mathematics and physics (Archetypes)
- Mathematics and science clubs (academic learners' life outside classroom) as a must for every school and the department should be enforcing these as the learners are getting intrinsically motivated in these clubs. These clubs should start in primary schools, Intermediate Phase.

- Mathematics and science cafés are a unique way of informal teaching and learning.

The educators mentioned the following difficulties that make learners perform poorly in algebraic graphs:

- The misconception they have that mathematics and physical sciences are difficult subjects
- Overcrowding in those classes as all the learners are doing mathematics and natural sciences
- Language barrier
- Lack of parental support and or assistance
- The learners become frustrated because of all the basic concepts they missed in previous grades, having to being emphasised at this level.
- Curriculum coverage pressure and completion of tasks creates confusion and immense pressure on the learners
- The inability of learners to grasp or the lack of the basics, e.g., graph or graphing skills, taught when discussing graphs, make it difficult for them to interpret and perform calculations on these graphs

The same problems cited the learners encounter with algebraic graphs, are also the difficulties causing them to struggle with kinematics graphs, e.g., graphing skills. This poor background in or inability to use prior knowledge of algebraic graphs have been cited as main source of learners' difficulties with kinematics graphs. Also lack of emphasis on the application and of the graphing skills both in algebraic and kinematics graphs contribute to learners' poor performance in kinematics. The other challenge the learners have are their inability to see a relationship between algebraic and kinematics graphs. They see these concepts as separate and abstract concepts not related to each other. The terminologies used in kinematics graphs to define quantities (average velocity, displacement, volume, etc.,) in algebra graphs is also something confusing to the learners, i.e., the lack of grasping the concepts or terminologies and language in kinematics graphs.

There are challenges that physics teachers say they encounter in the teaching of algebraic and kinematics graphs. Most of the problems are as listed above. The rowdy behaviour of learners due to adolescent stage makes it difficult for the educators to explain concepts in class and their lack of interest in the concept and subject. Most of

the time, the educator tries to maintain discipline and order in the classroom. Educators also come from work overload as well as lack of continuous professional development.

Can you describe the attitudes and approaches?

Educators claim that due to limited number of physical science teachers (one educators teaching all the grades) and a heavy workload load as stated above, educators don't get the opportunity to meet and teach algebraic and kinematics graphs from the other colleagues they are working with in the same subjects or other educators outside their schools (in physics and or mathematics teaching) nor even their seniors. There is not enough support system in terms of team teaching and or professional development. However, if an opportunity arise which is very rarely, educators tend to help each other as colleagues in the same subjects or in mathematics and physics, do they plan and prepare lessons together, attempt tasks, do summaries what they will all deliver on that specific day. Thereafter, they reflect on lessons and discuss how best we can assist learners.

In the progression from once having been a learner, a teacher trainee (student teacher) and currently a professional educator, educators experienced and practised to achieve good results from the learners through their own better performance, e.g., they found kinematics at first attempt being quite a challenge and with practice and delivery it became less of a challenge. The more educators have been exposed to the kinematics graphs concept from being a learner, a student teacher, a beginner educator, have made educators to overcome the challenges in teaching this concept and to be experience in and able to deal with those challenges. Adapting and understanding to curriculum at different levels of learners' learning (different grades) and their linkage, assist them to perform better in their teaching.

4.5 Conclusion

The findings of the qualitative study were given in this chapter, which also gave the insight into several other aspects that affected how well physical science educators taught algebraic and kinematics graphs, and how well do learners comprehend and learn the concept of algebraic and kinematics graphs. These also helped the researcher to investigate, to make deductions and respond to the research questions

on the perspectives of these educators and learners on the teaching and learning of kinematics and algebraic graphs, as well as what the document analysis of the CAPS document. The integrated deductions made from both qualitative and quantitative data are summarized in the illustration on the following chapter.

In the next chapter, the researcher will talk about the educators' knowledge categories and perceptions on the teaching and learning of algebraic and kinematics graphs, and as to how they contribute to efficient teaching methods. The learners' conceptual understanding on their learning and teaching strategies of kinematics and algebraic graphs will also be reported on to. Studies (Hurrell, 2021; NCTM, 2009) have shown that students' conceptual understanding is greatly influenced by instructional representations, which can come in a wide range of ways.

Chapter 5: Summaries, Conclusions and Recommendations

5.1 Introduction

This research study was mainly concerned with determining what or are the perceptions of high school physical science educators and learners in the Free State Province are on the content knowledge and conceptual understanding of graphs in algebra and kinematics. The study specifically investigated the context- and subject-specific issues that physical science educators in secondary schools faced in and outside their classrooms. The idea was to come up with alternative measures in the curriculum development of algebraic and kinematics graphs.

The premise of the research was based on cognitive skills and knowledge are paramount and significant importance in the academic and educational (teaching and learning) productivity and enhancement. The premise is due to the decline or poor performance of learners in algebraic and kinematics graphs, which escalated poor performance at tertiary level and to inability to retain or recruit learners and students in the mathematics and science streams or fields of study, the scarce skills sought by the government and country. Disadvantaged communities have been dominant and

syndrome in these inabilities and poor performance and a worrying trend locally, and nationally.

To achieve this aim of the study, five objectives were set as follows:

- What are the perceptions of high school teachers and learners on the teaching and learning of graphs in kinematics?
Which perceptions do high school teachers have on the teaching and learning of algebraic graphs in kinematics?
- How does physical science teachers relate the concepts in algebraic graphs and functions with concepts in kinematics graphs and equation?
- Do the national policy guidelines say anything regarding the teaching and learning of kinematics graphs in high schools?
- How does the background of high school physical science teachers impact on the use and applications of algebraic graphs and functions to solve kinematics graphs and equations?

In responding to these research questions, the researcher found it imperative to review literature related to them, the theoretical and conceptual framework as mentioned under the literature review chapter. The focus was on the factors that might contribute to poor performance of learners (learning) and the quality of education (teaching) the learners receive from the teachers and curriculum.

5.2 Summary of Main Findings

5.2.1 Overview of the Research

This research has been conceptualised into and based on two perspectives of teaching and learning kinematics and algebraic graphs in Grade 11. The learners' perspectives were investigated through their understanding and conceptual knowledge of algebraic and kinematics graphs. This was done with close ended questions to find if they can respond to questions in both algebraic and kinematics sections of the questionnaire. The questions were directly related or the same. The difference was the terminologies used in algebra and kinematics, which meant the same. The results of this investigation are illustrated and outlined in the chapter above.

The second approach was on how physical science educators perceive their teaching and how they perceive their learners' learning of algebraic and kinematics graphs. A

qualitative study was also conducted with the educators to get their and justify their responses in the quantitative data on how their learners learn and understand the two types of graphs and how the policies (document) assist in their teaching and the learners' learning. The responses from the educators were also captured in the above chapter.

The fact that school learners are not empty vessels when they enter the classroom has long since been established. This is because individuals form opinions or perceptions about events that occur in their environment from the earliest moments of life. It follows that knowledge should not just be imparted to the learners by their educators. It's true that learners enter science classes having a variety of non-scientific notions that may noticeably diverge from the scientific knowledge and conceptions the educator may be trying to instil in them.

It was hence imperative to investigate the perceptions of both educators and learners in recognition of this gap and prevalence as well as recognition of learners' prior learning as they move from one grade to the next, and as per expectations of the educators. This will help with learners' difficulty in the conceptual understanding of the relationship between algebraic and kinematics graphs, and how the clear conceptual understanding and knowledge of algebraic graphs can assist and be relevant them to solve kinematics graphs problems with open ended minds.

All these will assist in responding to the research questions as stated above.

5.3 The perceptions of the learners

The study will unveil the interpretation of the quantitative data collected from the learners to get their perceptions on their learning and understanding of algebraic and kinematics graphs. Previous studies (Phage et al, 2017; Small, et al, 2012, Basson, 2002, McDermott & Redish, 1999) have reiterated that learners are underperforming in kinematics graphs and are also unable to relate and apply prior algebraic concepts and knowledge in kinematics graphs and its problem-solving. It was therefore the imperatives of this study to deduce what the high school physical science learners think, or the perception deduced about the use, application and relation of algebraic graphs knowledge and skills with kinematics graphs.

5.3.1 High school learners' perceptions on the content knowledge of graphs in algebra

The perceptions of the learners on the content knowledge of algebraic graphs were determined from their performance based on the constructs as tabulated in Table 4.25.1. The results indicate that learners' performance is average and therefore do have minimal content knowledge in this concept of algebraic graphs. Hence content knowledge of algebraic graphs is not much of an issue to learners especially determining points on the graph but most of them are still struggling with determining the gradient. Perception shows that learners still are struggling with finding and calculating the gradient especially that will assist them with determining gradient of acceleration in a velocity-time graph. Minimal difficulty with gradient that help with finding gradient of velocity in a distance/displacement – time graph.

5.3.2 High school learners' perceptions on the conceptual understanding of graphs in algebra

The concepts that learners are taught and understand with algebraic graphs are same as those tabulated in Table 4.25.1. These are the concepts that learners must understand to be able to solve algebraic graphs problems, like plotting, analysing, and interpreting the graphs as well as do calculations based on the concepts or terminologies. Perceptions of learners on these conceptual understanding portray an average understanding with an above average understanding of identifying, plotting, or naming the coordinates of the graphs. The main challenge they experience and struggling are with gradient especially that will assist in determining acceleration.

5.3.3 High school learners' perceptions on the content knowledge of graphs in kinematics

The perceptions deducted from the learners on the content knowledge of graphs in kinematics were determined from their performance based on the constructs as tabulated in Table 4.25.2. The results from the learners' performance are far below average with performance around 20% except for points on the graph which is at about 50%. This depicts a poor performance by learner as compared to that in algebraic graphs.

This poor performance in the content knowledge poses a serious concern in the teaching and learning of kinematics graphs. It is either learners have negative attitude

and lack motivation/inspiration, or they lack the ability to apply their prior learning both in algebra and kinematics. Learners might also lack enough algebraic knowledge. This might be contrary to what have been depicted from learners' responses in the algebra graphs where more than 50% of them have shown to possess algebraic graphs skills and content knowledge. This might mean their educators, in kinematics, must put more emphasis, in their teaching of these constructs, on the relation to algebraic graphs and on the learners' recognition of their previous/prior knowledge.

5.3.4 High school learners' perceptions on the conceptual understanding of graphs in kinematics

Table 4.25.2 tabulated the concepts that learners were taught and had to understand on graphs in kinematics. The concepts were used to measure their understanding of kinematics graphs. The perception obtained from the learners' responses and poor performance, of around 20%, depict that learners lack a conceptual understanding of the topic. This might mean that the constructs in kinematics graphs have a rich and subtle meanings for the learners to comprehend.

Even though they show improvement in determining or using coordinates, with an average performance, a lot of emphasis is required to assist learners with struggling to understand these concepts. They might lack interest, confidence, and inspiration in learning kinematics graphs unlike in algebra graphs, which had more than half of participants showing conceptual understanding. This might also be due to the learners' inability to relate this content knowledge with that learnt in algebraic graphs. If so, an improved teaching strategy will have to be implemented and incorporated to impart algebra graphs skills and knowledge and recognition of learners' prior learning in teaching of the kinematics graphs.

5.4 Educators' perceptions

High school physical science educators have their own perceptions on the teaching and learning of graphs in kinematics and algebra. The interpretations of their perceptions in the study are therefore recorded as below.

5.4.1 Perceptions on high school teachers on the teaching and learning of algebraic graphs.

In the opinion of educators, teaching graphs is crucial because it exposes students to the world of data collection, prediction, comparison, analysis, and interpretation (as well as communication of conclusions). Graphs are useful because they summarize and simplify data from patterns that can be seen and assessed visually. They also support the learners in determining and interpreting the proportionality and relationship between different variables, whether they are independent or dependent.

Though most of the educators agreed that for them to teach kinematics graphs efficiently and effectively, they also need to teach algebraic graphs to reinforce the learners' background and prior knowledge required. The challenge was their workload if they must teach both subjects. They argued that their mathematics should suffice as they could not study physics without mathematics background. This also support what previous studies (Redish, 2006; Pietrocola, 2008; Phage, 2017) reiterated that mathematics is the language and tool of physics.

The physical science teachers also indicated that their problems of having to teach algebraic graphs are also minimised by the support they get from mathematics teachers, who most of them have physics background in their schools. With their monthly interactions, meeting and occasionally class visit of each other, they are able shed light with one another on relating concepts from different disciplines. That way they are able show their learners how algebraic graphs are related to kinematics graphs. It was demonstrated by previous researchers (Freitas, Jiménez & Mellado, 2004; Komati and Phage, 2011; Phage, et. Al., 2017,) that while completing experimental analyses and solving certain problems, most students who took part in the study did not integrate information from diverse scientific areas.

5.4.2 Perceptions on high school teachers on the teaching and learning of graphs in kinematics.

As stated in the above paragraph 5.4.1, teaching and learning of kinematics graphs, a physics topic/concept is largely dependent on the background of algebra graphs (mathematics). The educators believe that poor background and negative attitude the learners have towards physics make the teaching and learning of kinematics graphs a serious challenge. They alleged that learners have poor background and lack

motivation from lower grade where they would pass without knowledge, i.e., they would study and memorise to pass exam. This syndrome even persists and continues as they move to other grades.

Their learners have been moved to the other grade without passing the subject in the lower grades. They do physics out of parental pressure and or because they are assumed by the school to be capable or intelligent. Educators also confirm the learners lack or enough of and the inability to use, apply or relate algebraic graphs with kinematics graphs and hence struggle to solve problems in kinematics graphs. This is confirmed in the investigation of the learners' perceptions in paragraphs 5.3.2 5.3.3 above.

According to the educators, learners are confused and are having difficulties with the graph or graphing skills, expected, and learned from previous grades (recognition of prior learning). Though educators reiterate that they spent a lot of time trying to show the learners this prior learning, it only benefits very few as most learners have no interest or are lost when dealing with these concept of graphing skills. Learners' difficulties with graphing skills were investigated and reported by Freitas, et. al., (2004) and Phage, et. al., (2017).

The educators also blame lack of the parental support to their children (learners and lack of resources including the learners' living conditions. This is attested in paragraph 4.2.1 above that majority of learners (more than 60%) are from disadvantaged communities (farms, rural and townships).

5.5 The relation of the concepts in algebraic graphs and functions with concepts in kinematics graphs and equation - physical science teachers' perspectives

Regarding the relationship between algebraic and kinematics graphs, educators concur that both types of graphs show two variables on vertical and horizontal axes, one dependent and the other independent or fixed. In contrast, the variables of kinematics graphs rely on the type of equation, whereas the axes of algebraic graphs are the same regardless of the equation or function. Although the variables and attributes provide the same information, kinematics uses different terminology for them; for example, gradient in algebra is referred to as average velocity in kinematics.

Kinematics graph terminologies are defined by the terms in algebraic graphs. Educators repeated that you can determine average acceleration and average velocity, respectively, by computing the gradient of each graph based on the velocity-time and displacement-time patterns.

The educators further believed that it is of paramount significance that they incorporate and integrate algebraic skills in their teaching of kinematics, though this consumes their time for kinematics graph teaching. They essentially argued that teaching algebraic rules and trends should come first to aid students in understanding kinematics. After that, expand on that understanding and incorporate kinematics ideas. They emphasized that even though it takes more time, they will now be teaching algebra graphs rather than relying on the learners' prior knowledge from their algebra lesson.

They observed that majority of learners still have difficulties with drawing, analysing, and interpreting graphs in kinematics due to their lack of proper understanding of the terminologies meaning and units used in kinematics. Learners further confuse the plotting of axes for variables.

Educators believe that it would also therefore be necessary to draw the graphs from the viewpoint of coordinates and algebraic equations for comparison with kinematic equations of motion to teach learners how to plot kinematics graphs. By connecting these ideas, the problem-solving in kinematics graphs will be reinforced. They struggle to understand kinematics graphs and to explain the gradients and intercepts using concepts related to kinematics graphs. Learners struggle to grasp and depict motion graphs because they do not comprehend algebraic graphs or their analysis.

According to physical science educators, they need training and to possess constant physics skills and latest technologies to infuse in their in their kinematics graphs teaching classrooms. These will empower them to assist learners from performing poorly in both algebraic and kinematics graphs. They need to be able to handle and deals with:

The following issues were brought up by the teachers as reasons why students struggle with algebraic graphs:

- The false belief that the physical sciences and mathematics are abstract and challenging disciplines

- Overcrowding in those classrooms because all the learners are studying physical sciences and maths
- Communication gap (language barrier)
- Lack of parental guidance or support
- The fact that so many of the fundamental ideas that were neglected in earlier grades now need to be reinforced at this level irritates the learners.

Learners find it difficult to interpret and perform calculations on these graphs because of the following:

- The pressure of the curriculum and task completion creates confusion and immense pressure on the learners.
- Learners struggle to understand or lack the fundamentals, such as graphs or graphing skills, taught when discussing graphs.

Educators also think that for learners to comprehend and be familiar with the principles of kinematics graphs, they must first understand the fundamentals, which include dependent and independent variables, axes and their labels, points on the graphs, and the terminology and vocabulary used in the field. Their prior learning experience can also help educators recognize and correct common misconceptions they may have as well as enable them to draw more conclusions about typical kinematics graph errors that they as learners make. Providing learners with constant and frequent feedback and a variety of presentations that incorporate graphs, diagrams, mathematical equations, and other visual aids will help them recognize their areas of strength and weakness and advance their comprehension of the concepts of kinematics graphs.

5.6 The expectations of the national policy guidelines regarding the teaching and learning of kinematics graphs in high schools

The fourth research question for this investigation dealt with and was interested in the practical application on the rhetoric of policy (CAPS Document). Given the results of the document analysis, which indicated that the written as well as the intended curriculum supported the higher order knowledge and abilities expected from the learners and transferred by educators.

This help to address the extent to which a Grade 11 physical science educator practices could create learning opportunities for their learners to learn higher order cognitive processes and skills encapsulated and envisaged by the policy, CAPS. The summarised results for all the educators, using an analytical tool built around five types of connections that previous studies had found to be common in classroom interactions, show the distribution of educators' utterances, activities, and episodes in the order of prevalence.

5.7 The impact of the background of high school physical science teachers on the use and applications of algebraic graphs and functions to solve kinematics graphs and equations.

With only about 15% of educators with less than three years teaching experience, the perception is that majority of high school physical educators have background and expertise in teaching. Therefore, they should be able to use that background to apply algebraic graphs and functions to solve kinematics graphs and equations.

The challenge exposed was that about 55% have no mathematics teaching experience and about 13% have very little (less than three years) of this experience. This will impact largely on how they apply and use the algebraic graphs and functions in teaching and how their learners solve kinematics graphs and equations. To teach kinematics graphs and equations effectively and efficiently, it might be significant that a physical science educators must be familiar with how learners comprehend algebraic graphs and functions. This is complemented and confirmed by the assertion that majority (88%) of educators are of the perception that to teach kinematics graphs and equations (physics) effectively and efficiently, one needs to also teach algebraic graphs and functions.

To support this also, majority of physical science educators are still confident to teach kinematics graphs and equations while a very of them are looking for better prospects like promotion and other positions in physics. On the concept or topic of mechanics, which incorporates kinematics graphs and equations, most (91%) of these educators are confident and comfortable to teach it.

The impact of the background of the teachers to use and apply algebraic graphs and functions to solve kinematics graphs and equations is also supported and boosted by the majority of teachers' ability on the interactions with their fellow or other educators

on specific aspects and have discussions about how to teach a particular concept, working on preparing instructional materials, visits to another teacher's classroom to observe his/her teaching, informal observations of my classroom by another teacher, participation in professional development in physics content, integrating information technology into physics, improving learners' critical thinking or inquiry skills in physics assessment.

Educators also cited other factors that impacted negatively to teaching especially and in relation to the use and applications of algebraic graphs and functions to solve kinematics graphs and equations. Educators found it challenging to convey concepts in class because of the rowdy behaviour of adolescents and their lack of interest in the subject matter. The educator tries to keep the classroom in order and disciplined most of the time. A combination of work stress and a lack of ongoing professional development can also affect educators.

In terms of professional growth and/or team teaching, the perception is that there is insufficient or enough support infrastructure. But when the chance arises—which it seldom does, educators do have a chance to support one another as colleagues in the same topics, such as physics and mathematics. They collaborate to plan and prepare courses, take on chores, and write summaries of what each of them will teach that day. After that, they talk about how they can help their learners the most while reflecting on the lessons.

Along the way, educators have learned how to improve their own performance to attain better results from their learners. For example, educators who have previously been learners, pre- service teachers (student teachers), and lastly professional educators have learned how to overcome challenges in the areas of kinematics graphs and how to effectively teach it. Educators have become more experienced and equipped to handle the difficulties that arise when teaching the idea of kinematics graphs because they have been exposed to it more as learners, student teachers, novice, and experienced educators. They can perform better as educators when they can adapt to and comprehend the material at various learning levels (different grades) and how it relates to them.

5.8 Conclusion

Most researchers (Brewer & Chin, 1998:104 According to Sandoval (2005) and Berland, L.K., Schwarz, C.V., Krist, C., Kenyon, L., Lo, A.S., and Reiser, B.J. (2016), the perception of past knowledge quality has a significant impact on the process of teaching and learning in science. Though educators have attempted this in their classrooms, it has been reported as futile exercise that cost the time to teach the current content, not allowing them to finish the syllabus in time. This cost the educators to reteach the learners what they have already learnt in previous grade rather than applying and recognizing their prior knowledge.

It will be necessary to study and teach based on what learners already know or have learnt if educators are able to investigate the nature of students' prior knowledge and identify students' alternative views. Therefore, to successfully implement conceptual change, teaching tactics should be informed by activity-based instructional approaches. To meet the varying cognitive demands of students and consider individual differences, a variety of instructional styles should be employed.

The results of the study indicate the different views from both high school physical science educators. Though learners have not much to say, i.e., not blaming the educators for their poor performance, about how they are taught and learn kinematics using the knowledge and skills of the algebra graphs, the findings indicate they lack proper prior knowledge and ability to apply and relate algebraic graphs knowledge to solve kinematics graphs.

The educators on the other hand are of the perception that they cannot be blamed for learners' poor performance in algebraic graphs. They cited various convincing arguments supported by the findings of the study. It will therefore be of trivial significance that all the challenges experienced by learners and those exposed by their educators. In this manner, learners will be able to perform better in using, relating, and applying algebraic graphs knowledge to solve kinematics graphs with an enhanced knowledge and skills for life-long learning. It will also help to ease the pressure on educators without doubt of their learners' inability. Prior knowledge and its recognition will assist learners in developing and having keen interest and roped into physics fields of study.

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APPENDICES

Appendix A – Approval to do research

Enquiries: MZ Thango
Ref: Notification of research: IB Phage
Tel: 051 404 9257/ 9207/ 082 537 2654
Email: MZ.Thango@fseducation.gov.za



District Directors
Motho District
Xhariep District
Lejweleputswa District

Dear Mr. Moloi, Mr. Magwa and Ms. P. Zonke

NOTIFICATION TO CONDUCT RESEARCH PROJECT IN YOUR DISTRICT BY IB PHAGE

The above mentioned candidate was granted permission to conduct research in your district as follows:

Topic: Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics.

1. List of schools involved: Albertina Sisulu, Aliwal North, Beang Tse Molemo, Hoërskool Koffiefontein, Ipetleng, Itokisetseng Bokamoso, Lere La Thuto, Masakhane, Olien, Philippolis, Reikaeletse, Springfontein, Thabo-Vuyo, Thapelong, Trompsburg, Wongalethu, Bodibeng, Boitlamo, Dr Reginald Cingo, Goudveld, Harmony, Hoerskool Bultfontein, Hoërskool Hentie Cilliers, Iphateng, Ipopeng, Kheleng, Letsete, Mamello, Mophate, Motsilela, Oziel Selele, Phehellang Secondary Lejweleputswa District Phehello, Phephetso, Rearabetswe, Refihletse, Repholositswe, Riebeeckstad, Unitas, Welkom, Atlehang, Bloemfontein, Bloemfontein, Bloemfontein South, Bohmer, Calculus, Dr Blok, Eunice Girls, Fichardtpark, Grey College, Headstart, Heatherdale, Hodisa Technical, Hoërskool Sentraal, Hts Louis Botha Tsh, Lekhulong, Navalsig, Petunia, Rosenhof, Sehunelo, Tsoseletso, and Vulamasango Secondary schools.

Target Population: Learners and teachers doing Physical Sciences in grades 10 to 12 in the selected Secondary schools.

- 2. Period of research:** From the first week of February 2021 until 30 September 2021. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours. The researcher is expected to request permission from the school principals to conduct research at schools.
- 3. Research benefits:** The improved realization that knowledge and skills of algebra functions and graphs will assist significantly in the in not only the teaching and learning of kinematics and its graphs but will enhance a better and enhanced conceptual understanding of kinematics and its graph. Hence teachers will have an improved confidence and be versatile and flexible in teaching of the concept. Learners also will also be able to relate to the concepts in their learning and be interactive in class, resulting in more interest in the subject, increased enrolment in the subject and ultimately increased performance and results in the subjects.
- 4.** Logistical procedures were met, in particular ethical considerations for conducting research in the Free State Department of Education.
- 5.** Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researchers to present the findings and recommendations to the relevant officials in the district.

Yours sincerely


DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

2020/08/04
DATE:

RESEARCH NOTIFICATION. IB PHAGE 29 JULY 2020. MOTHEO DISTRICT, XHARIEP & LEJWELEPUTSWA DISTRICTS
Strategic Planning, Research & Policy Directorate Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9257 Fax: (086) 6678 678

www.fsdoe.fs.gov.za

Enquiries: MZ Thango
Ref: Research Permission: IB Phage
Tel. 051 404 9257 / 9207 / 082 537 2654
Email: MZ.Thango@fseducation.gov.za

124 Springbok Road
Fauna
9301



Dear Mr. Phage

APPROVAL TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

This letter serves as an acknowledgement of receipt of your request to conduct research in the Free State Department of Education.

Topic: Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics.

1. **List of schools involved:** Albertina Sisulu, Aliwal North, Beang Tse Molemo, Hoërskool Koffiefontein, Ipetleng, Itokisetseng Bokamoso, Lere La Thuto, Masakhane, Olien, Philippolis, Reikaeletse, Springfontein, Thabo-Vuyo, Thapelong, Trompsburg, Wongalethu, Bodibeng, Boitlamo, Dr Reginald Cingo, Goudveld, Harmony, Hoerskool Bultfontein, Hoërskool Hentie Cilliers, Iphateleng, Ipopeng, Kheleng, Letsete, Mamello, Mophate, Motsilela, Oziel Selele, Phehellang Secondary Lejweleputswa District Phehello, Phephetso, Rearabetswe, Refihletse, Repholositswe, Riebeeckstad, Unitas, Welkom, Atlehang, Bloemfontein, Bloemfontein, Bloemfontein South, Bohmer, Calculus, Dr Blok, Eunice Girls, Fichardtpark, Grey College, Headstart, Heatherdale, Hodisa Technical, Hoërskool Sentraal, Hts Louis Botha Tsh, Lekhulong, Navalsig, Petunia, Rosenhof, Sehunelo, Tsoseletso, and Vulamasango Secondary schools.
2. **Target Population:** +- 2 teachers per school teaching Physical Sciences in grades 10 to 12, +- 20 grade 11 learners aged 16 years and above per school in the selected Secondary schools.
3. **Period of research:** From date of signature of this letter until 30 September 2020. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools.
4. The approval is subject to the following conditions:
 - 4.1 The collection of data should not interfere with the normal tuition time or teaching process.
 - 4.2. A bound copy of the research document or a CD, should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.
 - 4.3. You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
 - 4.4. The ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely


DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 04/08/2020

RESEARCH APPLICATION BY IB PHAGE, PERMISSION LETTER 29 JULY 2020. MOTHIBO, JOHANNESBURG & LEJWELEPUTSWA DISTRICTS
Strategic Planning, Research & Policy Directorate Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9257 Fax: (086) 6678 678

Enquiries: MZ Thango
Ref: Notification of research: IB Phage
Tel: 051 404 9257/ 9207/ 082 537 2654
Email: MZ.Thango@fseducation.gov.za

District Directors
Motho District
Xhariep District
Lejweleputswa District

Dear Mr. Moloi, Mr. Magwa and Ms. P. Zonke

NOTIFICATION TO CONDUCT RESEARCH PROJECT IN YOUR DISTRICT BY IB PHAGE

The above mentioned candidate was granted permission to conduct research in your district as follows:

Topic: Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics.

1. List of schools involved: Albertina Sisulu, Aliwal North, Beang Tse Molemo, Hoërskool Koffiefontein, Ipetleng, Itokisetseng Bokamoso, Lere La Thuto, Masakhane, Olien, Philippolis, Reikaeletse, Springfontein, Thabo-Vuyo, Thapelong, Trompsburg, Wongalethu, Bodibeng, Boitlamo, Dr Reginald Cingo, Goudveld, Harmony, Hoerskool Bultfontein, Hoërskool Hentie Cilliers, Iphateng, Ipopeng, Kheleng, Letsete, Mamello, Mophate, Motsillela, Oziel Selele, Phehellang Secondary Lejweleputswa District Phehello, Phephetso, Rearabetswe, Refihletse, Repholositswe, Riebeeckstad, Unitas, Welkom, Atlehang, Bloemfontein, Bloemfontein, Bloemfontein South, Bohmer, Calculus, Dr Blok, Eunice Girls, Fichardtpark, Grey College, Headstart, Heatherdale, Hodisa Technical, Hoërskool Sentraal, Hts Louis Botha Tsh, Lekhulong, Navalsig, Petunia, Rosenhof, Sehunelo, Tsosetso, and Vulamasango Secondary schools.

Target Population: Learners and teachers doing Physical Sciences in grades 10 to 12 in the selected Secondary schools.

- 2. Period of research:** From the date of signature of this letter until 30 September 2020. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours. The researcher is expected to request permission from the school principals to conduct research at schools.
- 3. Research benefits:** The improved realization that knowledge and skills of algebra functions and graphs will assist significantly in the in not only the teaching and learning of kinematics and its graphs but will enhance a better and enhanced conceptual understanding of kinematics and its graph. Hence teachers will have an improved confidence and be versatile and flexible in teaching of the concept. Learners also will also be able to relate to the concepts in their learning and be interactive in class, resulting in more interest in the subject, increased enrolment in the subject and ultimately increased performance and results in the subjects.
- 4. Logistical procedures were met, in particular ethical considerations for conducting research in the Free State Department of Education.**
- 5. Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researchers to present the findings and recommendations to the relevant officials in the district.**

Yours sincerely


DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 04/08/2020

RESEARCH NOTIFICATION: IB PHAGE 29 JULY 2020. MOTHEO DISTRICT, XHARIEP & LEJWELEPUTSWA DISTRICTS
Strategic Planning, Research & Policy Directorate Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9257 Fax: (086) 6678 678

www.fsdoe.fs.gov.za

Enquiries: MZ Thango
Ref: Research Permission: IB Phage
Tel. 051 404 9257/ 9207 / 082 537 2654
Email: MZ.Thango@fseducation.gov.za



124 Springbok Road
Fauna
9301

Dear Mr. Phage

APPROVAL TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

This letter serves as an acknowledgement of receipt of your request to conduct research in the Free State Department of Education.

Topic: Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics.

1. **List of schools involved:** Albertina Sisulu, Aliwal North, Beang Tse Molemo, Hoërskool Koffiefontein, Ipetleng, Itokisetseng Bokamoso, Lere La Thuto, Masakhane, Olien, Philippolis, Reikaeletse, Springfontein, Thabo-Vuyo, Thapelong, Trompsburg, Wongalethu, Bodibeng, Boitlamo, Dr Reginald Cingo, Goudveld, Harmony, Hoerskool Bultfontein, Hoërskool Hentie Cilliers, Iphateng, Ipopeng, Kheleng, Letsete, Mamello, Mophate, Motsilela, Oziel Selele, Phehellang Secondary Lejweleputswa District Phehello, Phephetso, Rearabetswe, Refihletse, Repholositswe, Riebeeckstad, Unitas, Welkom, Atlehang, Bloemfontein, Bloemfontein, Bloemfontein South, Bohmer, Calculus, Dr Blok, Eunice Girls, Fichardtpark, Grey College, Headstart, Heatherdale, Hodisa Technical, Hoërskool Sentraal, Hts Louis Botha Tsh, Lekhulong, Navalsig, Petunia, Rosenhof, Sehunelo, Tsosetso, and Vulamasango Secondary schools.
2. **Target Population:** +- 2 teachers per school teaching Physical Sciences in grades 10 to 12, +- 20 grade 11 learners aged 16 years and above per school in the selected Secondary schools.
3. **Period of research:** From the first week of February 2021 until 30 September 2021. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools.
4. The approval is subject to the following conditions:
 - 4.1 The collection of data should not interfere with the normal tuition time or teaching process.
 - 4.2. A bound copy of the research document or a CD, should be submitted to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein.
 - 4.3. You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
 - 4.4. The ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours sincerely


DR JEM SEKOLANYANE
CHIEF FINANCIAL OFFICER

DATE: 20/08/04

RESEARCH APPLICATION BY IB PHAGE, PERMISSION LETTER 29 JULY 2020. MOTHEO, KHARIEP & LEJWELEPUTSWA DISTRICTS
Strategic Planning, Research & Policy Directorate Private Bag X20565, Bloemfontein, 9300 - Old CNA Building, Room 318, 3rd Floor, Charlotte Maxeke Street, Bloemfontein
Tel: (051) 404 9283 / 9257 Fax: (086) 6678 678

Appendix B – Application to do research.

Ref: Research Application

APPLICATION TO REGISTER AND CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION

- Please complete all the sections of this form that are applicable to you. If any section is not applicable please indicate this by writing N/A.
- Attach all the required documentation so that your application can be processed.
- Send the completed application to:

DIRECTOR: STRATEGIC PLANNING, POLICY AND RESEARCH

Room 319, 3rd Floor
Old CNA Building
Bloem Plaza
Charlotte Maxeke Street
BLOEMFONTEIN, 9300

OR

Free State Department of Education
Private Bag X20565
BLOEMFONTEIN, 9300

Email: MZ.Thango@fseducation.gov.za and K.Motshumi@fseducation.gov.za

PLEASE DO NOT EMAIL ANYTHING IN PICTURE FORMAT

Tel: 051 404 9283 / 9211 / 082 454 1519

RESEARCH APPLICATION PHASE IB FORM SEND 2 SEPT 2019

Private Bag X20565, Bloemfontein, 9300 Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein, 9301

Tel: (051) 404 9283 / 9221 Fax: (086) 6678 678

1. **TITLE** (e.g. Ms., Mrs., Mr., Dr, Prof, etc.):

Mr.

2. **INITIALS**

IB

3. **SURNAME**

Phage

4. **TELEPHONE HOME:**

082 338 9259

5. **TELEPHONE WORK:**

051 507 3827

6. **TELEPHONE CELL:**

082 338 9259

7. **FAX:**

086 656 7253

8. **E-MAIL**

phageh@gmail.com and iphage@cut.ac.za

9. **ADDRESS HOME:**

124 Springbok Road

Fauna

Postal Code: 9301

10. **ADDRESS WORK:**

Department of Mathematics, Science and Technology Education

Central University of Technology, Free State (Bloemfontein Campus)

20 President Brand Street

Bloemfontein

Postal Code: 9301

11. **POSTAL ADDRESS**

124 Springbok Road

FAUNA

Postal Code: 9301

12. NAME OF TERTIARY INSTITUTION / RESEARCH INSTITUTE / WHERE REGISTERED FOR RESEARCH

Central University of Technology, Free State

13. STUDENT NUMBER

217011797

14. PLACE OF EMPLOYMENT AND POSITION

Bloemfontein Campus
Lecturer

15. NAME OF COURSE /QUALIFICATION REGISTERED

Doctor of Education (D. Ed.)

16. NAME OF SUPERVISOR / PROMOTER & CONTACT DETAILS

SUPERVISOR
Surname and initials: Dr Bhagwande R
Email: rgupta@cut.ac.za
Cell number: +27 78 830 9779 / +27 79 661 5886
CO-SUPERVISOR
Surname and initials: Percy Sepeng (Prof)
Email: psepeng@cut.ac.za
Cell number: +27 79 661 5886
Tel: +27 51 507 3025 (Office)

17. TITLE OF RESEARCH PROJECT

Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics

18. CONCISE EXPLANATION OF THE RESEARCH TOPIC

It will investigate what hampers or what lead to learners' poor performance in the subject (physics), what challenges physical science teachers are facing with in the teaching of the concepts or subject, and in what ways can teachers can teachers' motivate their learners to take and have interest in physical science as their subject of choice and improved performance/results in matric and all other grades.

19. APPLICATION VALUE THAT THE RESEARCH MAY HAVE FOR THE FREE STATE EDUCATION DEPARTMENT

The improved realization that knowledge and skills of algebra functions and graphs will assist significantly in the in not only the teaching and learning of kinematics and its graphs but will enhance a better and enhanced conceptual understanding of kinematics and its graph. Hence teachers will have an improved confidence and be versatile and flexible in teaching of the concept. Learners also will also be able to relate to the concepts in their learning and be interactive in class, resulting in more interest in the subject, increased enrolment in the subject and ultimately increased performance and results in the subjects

20. LIST OF SCHOOLS AND DISTRICTS INVOLVED IN THE RESEARCH

- List schools alphabetically per district.
- Number schools per district
- If not enough space, please add more rows. Alternatively delete rows
- Research students, who are educators, are not allowed to conduct research at the school where they are teaching.

Schools	Districts
ALBERTINA SISULU SECONDARY SCHOOL	XHARIEP DISTRICT
ALI WAL NORTH HIGH SCHOOL	XHARIEP DISTRICT
BEANG TSE MOLEMO SECONDARY SCHOOL	XHARIEP DISTRICT
HOERSKOOL KOFFIEFONTEIN	XHARIEP DISTRICT
IPETLENG SECONDARY SCHOOL	XHARIEP DISTRICT
ITOKISETSENG BOKAMOSO SECONDARY SCHOOL	XHARIEP DISTRICT
LERE LA THUTO HIGH SCHOOL	XHARIEP DISTRICT
MASAKHANE SECONDARY SCHOOL	XHARIEP DISTRICT
OLIEN SECONDARY SCHOOL	XHARIEP DISTRICT
PHILIPPOLIS SECONDARY SCHOOL	XHARIEP DISTRICT
REIKAELETSE SECONDARY SCHOOL	XHARIEP DISTRICT
SPRINGFONTEIN SECONDARY SCHOOL	XHARIEP DISTRICT
THABO-VUYO SECONDARY SCHOOL	XHARIEP DISTRICT
THAPELONG SECONDARY SCHOOL	XHARIEP DISTRICT
TROMPSBURG SECONDARY SCHOOL	XHARIEP DISTRICT
WONGALETHU SECONDARY SCHOOL	XHARIEP DISTRICT
BODIBENG SEC SCHOOL	LEJWELEPUTSWA DISTRICT
BOITLAMO SECONDARY	LEJWELEPUTSWA DISTRICT
DR REGINALD CINGO SEC	LEJWELEPUTSWA DISTRICT
GOUDVELD SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
HARMONY HIGH SCHOOL	LEJWELEPUTSWA DISTRICT
HOERSKOOL BULTFONTEIN	LEJWELEPUTSWA DISTRICT
HOERSKOOL HENTIE CILLIERS	LEJWELEPUTSWA DISTRICT
IPHATELENG HIGH SCHOOL	LEJWELEPUTSWA DISTRICT
IPOPENG SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
KHELENG SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
LETSETE SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
MAMELO SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
MOPHATE SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
MOTSLILELA SECONDARY	LEJWELEPUTSWA DISTRICT
OZIEL SELELE SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
PHEHELLANG SECONDARY	LEJWELEPUTSWA DISTRICT
PHEHELLO HIGH SCHOOL	LEJWELEPUTSWA DISTRICT

Schools	Districts
PHEPHETSO SECONDARY	LEJWELEPUTSWA DISTRICT
REARABETSWA SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
REFIHLETSE COMBINED SCHOOL	LEJWELEPUTSWA DISTRICT
REPHOLOSITSWE SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
RIEBEECKSTAD SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
UNITAS SECONDARY SCHOOL	LEJWELEPUTSWA DISTRICT
WELKOM HIGH SCHOOL	LEJWELEPUTSWA DISTRICT
ATLEHANG SECONDARY SCHOOL	MOTHEO DISTRICT
BLOEMFONTEIN HIGH SCHOOL	MOTHEO DISTRICT
BLOEMFONTEIN HIGH SCHOOL	MOTHEO DISTRICT
BLOEMFONTEIN SOUTH HIGH SCHOOL	MOTHEO DISTRICT
BOHMER SECONDARY SCHOOL	MOTHEO DISTRICT
CALCULUS HIGH SC	MOTHEO DISTRICT
DR BLOK SECONDARY SCHOOL	MOTHEO DISTRICT
EUNICE GIRLS HIGH SCHOOL	MOTHEO DISTRICT
FICHARDTPARK HIGH SCHOOL	MOTHEO DISTRICT
GREY COLLEGE SECONDARY SCHOOL	MOTHEO DISTRICT
HEADSTART HIGH SCHOOL	MOTHEO DISTRICT
HEATHERDALE COMPREHENSIVE SECONDARY SCHOOL	MOTHEO DISTRICT
HODISA TECHNICAL SECONDARY SCHOOL	MOTHEO DISTRICT
HOERSKOOL SENTRAAL	MOTHEO DISTRICT
HTS LOUIS BOTHA THS	MOTHEO DISTRICT
LEKHULONG SECONDARY SCHOOL	MOTHEO DISTRICT
NAVALSIG SECONDARY SCHOOL	MOTHEO DISTRICT
PETUNIA SECONDARY SCHOOL	MOTHEO DISTRICT
ROSENHOF HIGH SCHOOL	MOTHEO DISTRICT
SEHUNELO SECONDARY SCHOOL	MOTHEO DISTRICT
TSOSELETSO HIGH SCHOOL	MOTHEO DISTRICT
VULAMASANGO HIGH SCHOOL	MOTHEO DISTRICT

21. LIST OF DIRECTORATES / OFFICIALS IN THE DEPARTMENT INVOLVED IN THE RESEARCH

Officials indicated in this paragraph should also be included in Paragraph 22.

Directorate/s	Position and names of Officials	Role of officials in the research
N/A	N/A	N/A

22. DETAILS OF TARGET GROUP WITH WHOM THE RESEARCH IS TO BE UNDERTAKEN

Target group	Number	Grade	Subject	Age	Gender	Language
Teachers	+/- 2 per school	10 - 12	Physical Science	N/A	Both Females and Males	English
Learners	+/-20 per school	11	Physical Science	16 years and above	Both Females and Males	English

23. FULL PARTICULARS OF HOW INFORMATION WILL BE OBTAINED FROM EACH OF THE TARGET GROUPS (as indicated in paragraph 22), e.g.: through questionnaires, standardized tests, interviews, observations, focus group discussions and/or other quantitative, qualitative, participatory action research strategies. Please attach tool to be used with each target group and explain how you will safeguard minor learners as per the children's act, if applicable.

Two research instruments will be used to collect data namely, a questionnaire and interviews. The researcher will administer both the questionnaire and the interviews to the teachers. Interview questions will be designed and deduced from responses to questionnaire (after data analysis). Questionnaires will be administered amongst all selected school physical science teachers and Grade 11 learners. Follow up interviews will be conducted with a focus group from the teachers, at least 4 teachers per district.)

24. STARTING AND COMPLETION DATES FOR GATHERING DATA AT THE SCHOOL/PLACE WHERE YOU WILL GATHER DATA FOR THE RESEARCH?

Please bear in mind that research is usually not allowed to be conducted in schools during the fourth academic term (October to December).

List as per each district
 XHARIEP DISTRICT : 24 August 2020 – 04 September 2020
 LEJWELEPUTSWA DISTRICT: 07 September 2020 – 18 September 2020
 MOTHEO DISTRICT: 21 September 2020 – 30 September 2020

25. WILL THE RESEARCH BE CONDUCTED DURING OR AFTER SCHOOL HOURS?

Please bear in mind that research is not allowed to be conducted in schools during normal teaching time.

After school hours between 14:00 and 15:00.

26. HOW MUCH TIME IS NEEDED WITH THE TARGET GROUP/S TO CONDUCT THE RESEARCH?

In a case where minors are part of the target group, please indicate who else will be at school to ensure their safety (e.g. teacher/principal/parents etc.).

Target Group	Activity (i.e. interview, questionnaire, focus group discussions, etc.)	Time Needed Starting and Finishing Time (daily, weekly, monthly)
Teachers XHARIEP DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 24 August 2020 – 04 September 2020
Learners XHARIEP DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 24 August 2020 – 04 September 2020
Teachers LEJWELEPUTSWA DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 07 September 2020 – 18 September 2020
Learners LEJWELEPUTSWA DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 07 September 2020 – 18 September 2020
Teachers MOTHEO DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 21 September 2020 – 30 September 2020
Learners MOTHEO DISTRICT	Questionnaire	Monday to Friday 2 pm to 3 pm (Daily) 21 September 2020 – 30 September 2020
Teachers XHARIEP DISTRICT	Interviews	18 January 2021 – 22 January 2021 (Daily - one day per school)

Target Group	Activity (i.e. interview, questionnaire, focus group discussions, etc.)	Time Needed Starting and Finishing Time (daily, weekly, monthly)
Teachers LEJWELEPUTSWA DISTRICT	Interviews	25 January 2021 – 29 January 2021 (Daily - one day per school)
Teachers MOTHEO DISTRICT	Interviews	05 February 2021 – 05 February 2021 (Daily - one day per school)

27. HAVE YOU INCLUDED / ATTACHED?

27.1 A letter from your supervisor confirming your registration for the course you are following?

Yes	No	N/A
X		

27.1 A draft letter / specimen that will be sent to principals requesting permission to conduct research in their schools?

Yes	No	N/A
X		

27.2 A draft letter / specimen that will be sent to parents requesting permission for their children to participate in the research project?

Yes	No	N/A
X		

27.3 A draft letter / specimen that will be sent to research participants to give their consent to take part in the research project?

Yes	No	N/A
X		

27.4 A copy of the questionnaires that you wish to distribute to the target group/s?

Yes	No	N/A
X		

27.5 A list of questions that will be asked during interviews with the target group/s?

Yes	No	N/A
X		

NB! Interview questions to be designed after and from quantitative data analysis

27.6 Ethical clearance certificate from higher education institution

Yes	No	N/A
X		

28 I, Itumeleng Barnard Phage herewith confirm that all the information in this application form is correct and that I will abide by the ethical code and the conditions under which the research may be undertaken, i.e.:

- 28.1 I will abide by the ethical research conditions in the discourse of my study in the FSDoE.
 - 28.2 I will not use deception on people participating.
 - 28.3 I will obtain informed consent from all involved in the study.
 - 28.4 I will preserve privacy and confidentiality at all the time.
 - 28.5 I will take special precautions when involving populations which may not be considered to understand fully the purpose of the study.
 - 28.6 I will not offer rewards or enforce binding contracts for the study. This is especially important when people are somehow reliant on the reward.
 - 28.7 I will not skew their conclusions based on funding.
 - 28.8 I will not commit science fraud, falsify research or otherwise conduct scientific misconduct
 - 28.9 My research will follow all regulations given.
 - 28.10 I will not plagiarize the work of others
 - 28.11 I will abide by the period in which the research has to be done
 - 28.12 I will apply for extension if I cannot complete the research within the specified period
 - 28.13 I will not conduct research during the fourth quarter of the academic year
 - 28.14 I will not disrupt normal learning and teaching times at schools to undertake my research
 - 28.15 I will submit a bound copy or CD of the research document to the Free State Department of Education, Room 319, 3rd Floor, Old CNA Building, Charlotte Maxeke Street, Bloemfontein, upon completion of the research.
 - 28.16 I will upon completion of my research study make a presentation to the relevant stakeholders in the Department as per the arrangements of the Department.
 - 28.17 The costs relating to all the conditions mentioned above are for my own responsibility.
- 29 THE DATE THAT I WILL BE HANDING MY RESEARCH TO THE FREE STATE DEPARTMENT OF EDUCATION AFTER COMPLETION OF MY STUDIES: 30 NOVEMBER 2021

SIGNATURE APPLICANT:



DATE: 30/07/2020

INITIALS AND SURNAME OF SUPERVISOR: Dr R Bhagwandeem

SIGNATURE SUPERVISOR :



DATE: 30/07/2020

INITIALS AND SURNAME OF CO-SUPERVISOR: P Sepeng (Prof)

SIGNATURE SUPERVISOR :



DATE: 30/07/2020

ETHICAL REQUIREMENTS : FREE STATE DEPARTMENT OF EDUCATION

The scientific research enterprise is built on a foundation of trust and that the reports by others are valid. The reports should reflect an honest attempt by the researcher to describe the world accurately and without bias; this trust will endure only if the researcher devotes himself or herself to exemplifying and transmitting the values associated with ethical research conduct.

There are many ethical issues to be taken into serious consideration when conducting research. The Free State Department of Education believes that the researchers conducting research in this department would, amongst others, adhere to the following ethical conduct:

1. Be aware of having the responsibility to secure the actual permission and interests of all those involved in the study;
2. Not misuse any of the information discovered
3. Moral responsibility maintained towards the participants
4. Embracing corporate social responsibility
5. Protecting the rights of people in the study as well as their privacy and sensitivity
6. Confidentiality of those involved in the observation must be carried out, keeping their anonymity and privacy secure.
7. Follow the ethical clearance guideline of the institution that granted such.
8. Reliability
9. Informing the participants about the importance of the research
10. Values of trust, fairness and integrity are maintained in the study.
11. The value of transparency is considered.
12. The research is committed to delivering the intended promise as informed by the objectives.
13. The research accentuates the values of reputation and respect.
14. I will not conduct research at the school where I am teaching.
15. I am not listed in the national register of sexual offenders.

IB Phage



24/07/2020

RESEARCHER: INITIALS AND SURNAME

SIGNATURE:

DATE:

Dr R Bhagwandeem



24/07/2020

SUPERVISOR: INITIALS AND SURNAME

SIGNATURE

DATE:

P Sepeng (Prof)



24/07/2020

SUPERVISOR: INITIALS AND SURNAME

SIGNATURE

DATE:

Appendix C - Research Ethics Approval



RESEARCH ETHICS APPROVAL

Date: 10 December 2019

This is to confirm that:

Applicant's Name and student number	Mr I Phage 217011797
Supervisor's Name for Student Project	Dr R Bhagwandeem (Supervisor)
Level of Qualification for Student's Project	D.Ed
Title of research project	Physical science teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics

Ethical clearance has been provided by the Faculty Research and Innovation Committee [01/06/16] in view of the CUT Research Ethics and Integrity Framework, 2016 with reference number [D.FRIC.18.5.22]

All conditions as set out below have to be met as set out in your LS 262 a form.

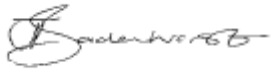
Ethical considerations:

As this research focuses primarily on human beings you will be ethically responsible for:

- protecting the rights and welfare of the participants;
- gaining the trust and co-operation of all the participants with the assurance that the information collected will be kept confidential;
- informing the participants from the outset that their participation will be voluntary, and that the data collected will be conducted with the consent of the Free State Department of Education, the principal(s) of the sample school(s), the teachers, and the learners;
- adhere to the principles of rigorous data collection, analysis and interpretation consistently with the design of the study;
- keeping a data trail for possible auditing purposes and safe-keeping of raw data for a period of three years after publishing the results;
- respecting the confidentiality of the data.

We wish you success with your research project.

Regards



Prof JW Badenhorst
(Chairperson representative: Research with humans/Faculty of Humanities)

Appendix D – Letter of study confirmation from promoter



Central University of
Technology, Free State

■ Welkom Campus

Department of Mathematics, Science and Technology Education

30th January 2020

To Whom It May Concern:

I, the undersigned hereby confirm that Mr I B Phage student number 217011797 is a registered D.Ed. student and I am his supervisor.

Topic of his study is

"Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics"

I hope you will find this information in order.

Best wishes



Dr. R. Bhagwande" Pro.Sci.Nat"
Lecturer: Chemistry

Departmental Manager: Mathematics, Science & Technology Education, Welkom
Faculty of Humanities

Tel: +27 57 910 3570 | E-mail: rgupta@cut.ac.za
Cell: +27 78 830 9779 / +27 79 661 5886

Welkom • PO Box 1881 • WELKOM • SOUTH AFRICA • 9460 •
Tel: +27 57 910 3570 • E-mail: rgupta@cut.ac.za • Website: www.cut.ac.za

Appendix E – Learners' questionnaire

QUESTIONNAIRE - GRADE 11 PHYSICAL SCIENCE LEARNERS

Respondent Number

The purpose of this questionnaire is to obtain information on my content knowledge and conceptual understanding of graphs in algebra (mathematics) and kinematics (physical science) to improve its teaching and learning.

I understand that participation in this research is completely confidential, voluntary and no pressure may be placed on me to participate. I understand that it is not a test that will count any marks and or used against me. I hereby give permission and consent that this questionnaire will be strictly used for research purposes.

Signed at (Place) _____

Signature

Date

Section A: Biographical Data

A1. How old are you?

A2. Are you female or male?

Female	1
Male	2

A3. Type of your school

Public/government	1
Private	2

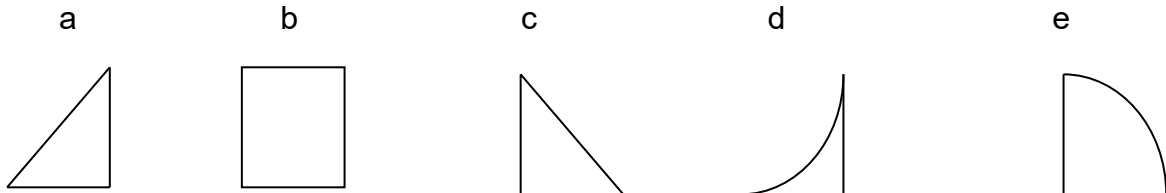
A4. How many times are you doing Grade 11?

1	2	3
First time	Second time	More than two times

Section B: Algebraic Graphs

Five options are given to the multiple-choice items below. Please cross the number (1, 2, 3, 4 or 5) of the correct answer

B1.1. Of the geometric figures below, which one has the greatest area? Assume that all the figures have the same width and height.

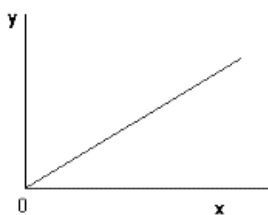


1. a
2. b
3. c
4. d
5. e

B1.2. Of the geometric figures in B1.1 above, which one has the smallest area? Assume that all the figures have the same width and height.

1. a
1. b
2. c
3. d
4. e

B2. Consider the graph below. With increasing x , the gradient is:



- 1 Zero
- 2 Increasing
- 3 Decreasing
- 4 Constant
- 5 Varying

B3. The equation of the given graph is:

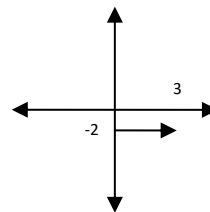
1 $x = 3$

2 $y = -2$

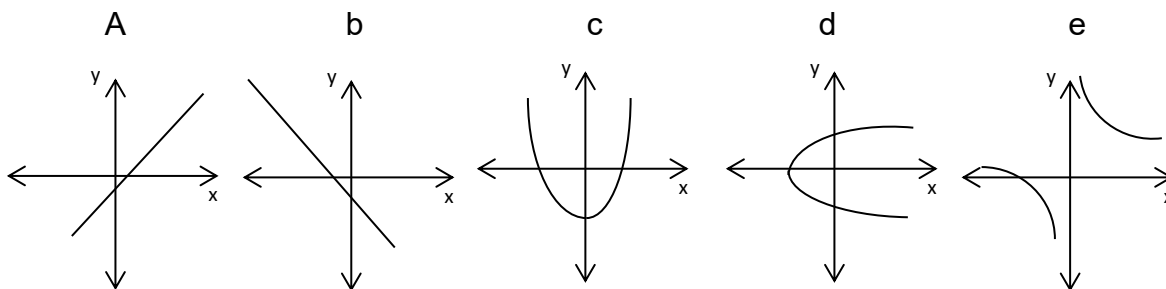
3 $y = 3x - 2$

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

5 $y = -2x + 3$



B4. Choose the answers of the questions below from the following graph forms.



B4.1. Which one of the graphs shows the function $f(x) = x - 1$?

1 a

2 b

3 c

4 d

4 e

B4.2. Which one of the graphs shows the function $g(x) = \frac{2}{x}$?

1 a

2 b

3 c

4 d

5 e

B4.3. Which one of the graphs shows the function $h(x) = x^2 - 1$?

1 a

2 b

3 c

4 d

5 e

B5. The gradient of the given graph is:

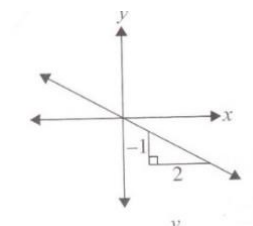
1 +2

2 -2

3 $+\frac{1}{2}$

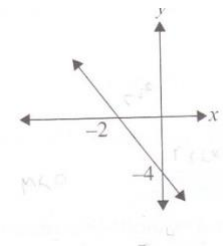
4 $-\frac{1}{2}$

5 0

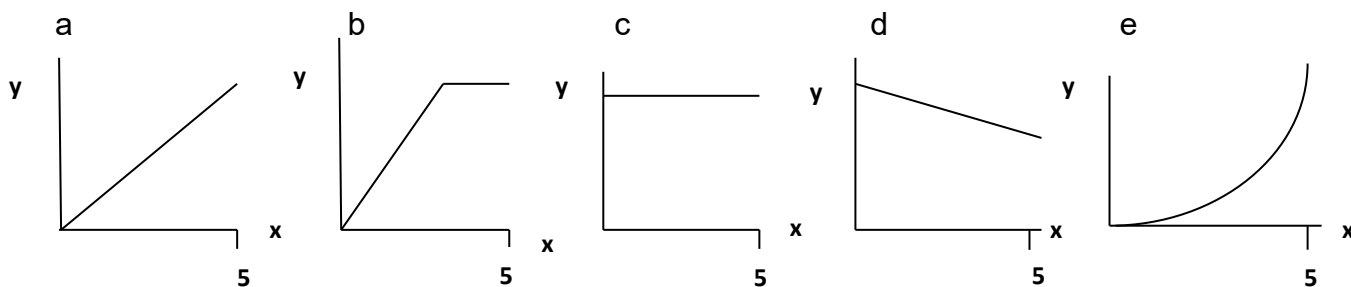


B6. The gradient of the given graph is:

- 1 + 2
- 2 - 2
- 3 + $\frac{1}{2}$
- 4 - $\frac{1}{2}$
- 5 - 4



B7. Choose the answers to questions below from the following graphs. In all these graphs the maximum values for y are the same.



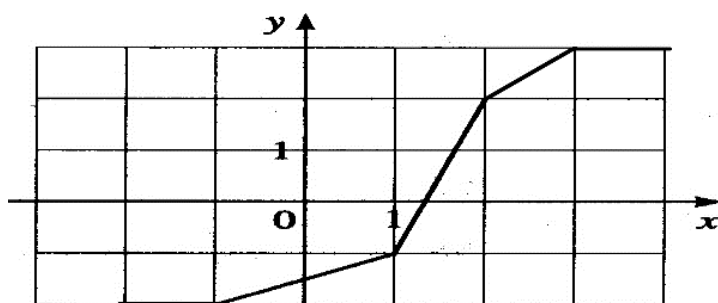
B7.1. Which one of the graphs has the smallest area under the graph from $x=0$ to $x=5$?

- 1 a
- 2 b
- 3 c
- 4 D
- 5 e

B7.2. Which one of the graphs has the largest area under the graph from $x = 0$ to $x = 5$?

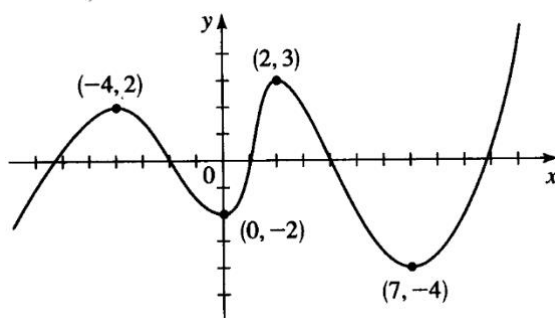
- 1 a
- 2 b
- 3 c
- 4 d
- 5 e

B8. In which of the intervals is the gradient of the graph the largest?



- 1 $-2 < x < -1$
- 2 $-1 < x < 1$
- 3 $1 < x < 2$
- 4 $2 < x < 3$
- 6 $3 < x < 4$

B9. Consider the graph of a function shown in the figure



In each one of the questions below the intervals are labelled as follows:

- a $-4 < x < -2$
- b $-2 < x < 0$
- c $0 < x < 1$
- d $1 < x < 2$
- e $2 < x < 4$
- f $4 < x < 7$

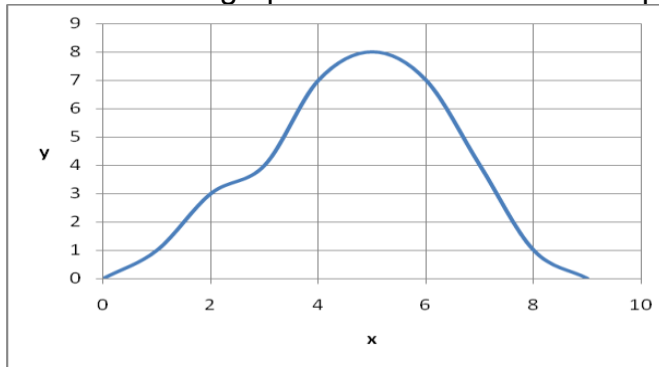
B9.1. In which of the intervals is the function increasing?

- 1 c, d, e, f
- 2 only c, d
- 3 a, d, e
- 4 only d

B9.2. In which of the intervals is the gradient positive?

- 1 c, d, e, f
- 2 only c, d
- 3 a, d, e
- 4 only d

B10. Use the graph below and answer the questions that follow:



B10.1. What are the coordinates of the turning point in the graph?

1. (0;5)
2. (5;8)
3. (8;5)
4. (0;8)
5. (9;8)

B10.2. What is the value of y if $x = 4$?

1. 4
2. 0
3. 7
4. 3
5. 8

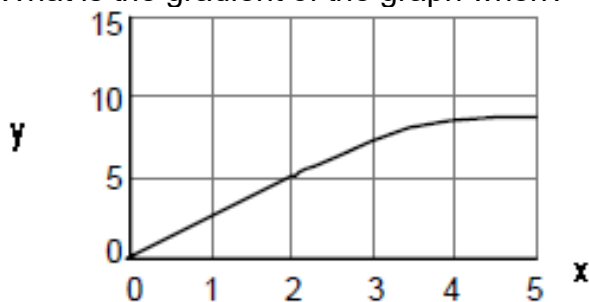
B10.3. What are the values of x if $y = 4$?

1. 3 and 7
2. $2\frac{1}{2}$ and $6\frac{1}{2}$
3. $3\frac{1}{2}$ and $7\frac{1}{2}$
4. Only $2\frac{1}{2}$
5. Only 3

B10.4. From $x = 4$ to $x = 5$ the gradient

1. increases
2. decreases
3. is constant
4. Not possible to tell

B11. What is the gradient of the graph when?



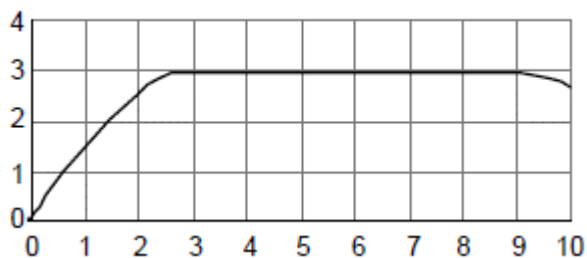
B11.1. $x = 2$?

- 1 0.4
- 2 2.0
- 3 2.5
- 4 5.0
- 5 10.0

B11.2. $x = 4.5$?

- 1 5
- 2 0
- 3 $8 / 4.5$
- 4 $4.5 / 8$
- 5 8

B12. Consider the following graph:



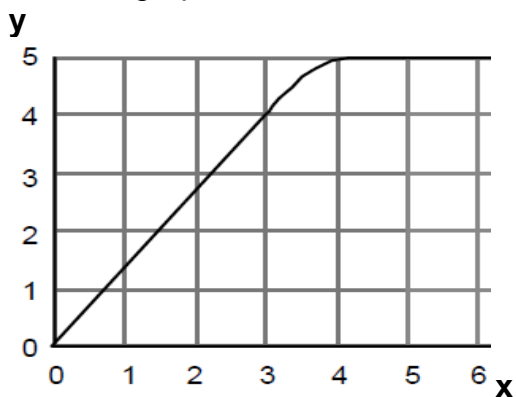
B12.1. The area under the graph in the x-interval (4, 8) is:

- 1 0
- 2 1.33
- 3 4.0
- 4 12.0
- 5 24.0

B12.2. The gradient of the graph in the x-interval (4, 8) is:

- 1 0
- 2 0.75
- 3 1.33
- 4 4.0
- 5 12.0

B13. For the graph below, answer the following questions:



B13.1. How does the value of y change between $x = 4$ and $x = 6$?

- 1 Increases
- 2 Decreases
- 3 Remains constant.
- 4 Zero
- 5 Not possible to tell.

B13.2. The gradient for the interval $4 < x < 6$ is:

- 1 Positive
- 2 Negative
- 3 Zero
- 4 Unknown
- 5 Not possible to tell.

B13.3. How does the value of y change between $x = 0$ and $x = 3$?

- 1 Increases
 - 2 Decreases
 - 4 Remains constant
 - 4 Zero
- Not possible to tell.

B13.4. The gradient for the interval $0 < x < 3$ is:

- 1 Positive
- 2 Negative
- 3 Zero
- 4 Unknown
- 5 Not possible to tell.

B13.5. What is the area under the graph for $0 < x < 3$?

- 1 0.75
- 2 1.33
- 3 4.0
- 4 6.0
- 6 12.0

E1.

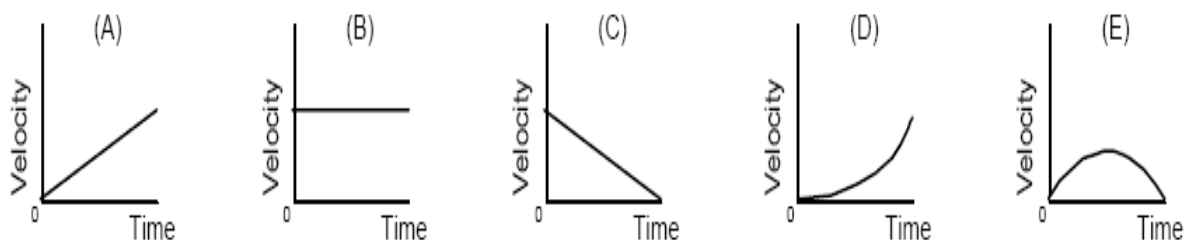
For office use only	
Total Algebraic graphs score	

THANK YOU VERY MUCH!

SECTION C: Questions on graphs in physics (Kinematics Graphs and Equation)

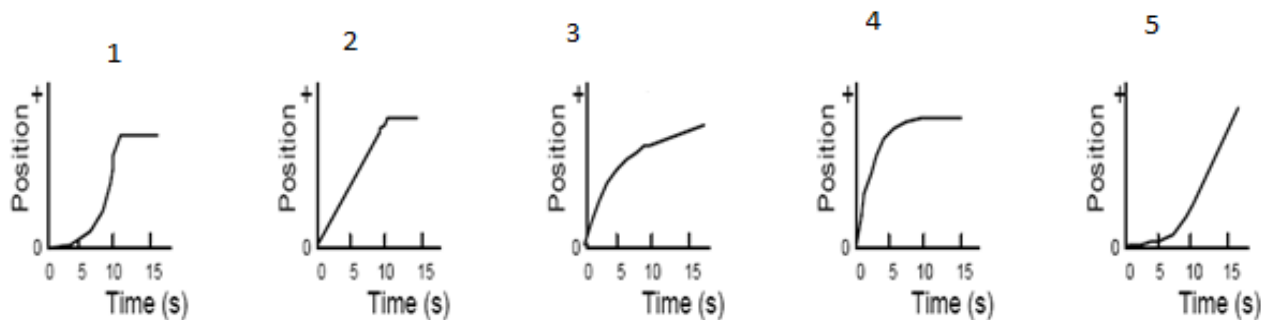
Five options are given to the multiple-choice items below. Please cross the number (1, 2, 3, 4 or 5) of the correct answer

C1. Velocity versus time graphs for five objects are shown below. All axes have the same scale. Which object had the greatest change in position (displacement) during the interval?

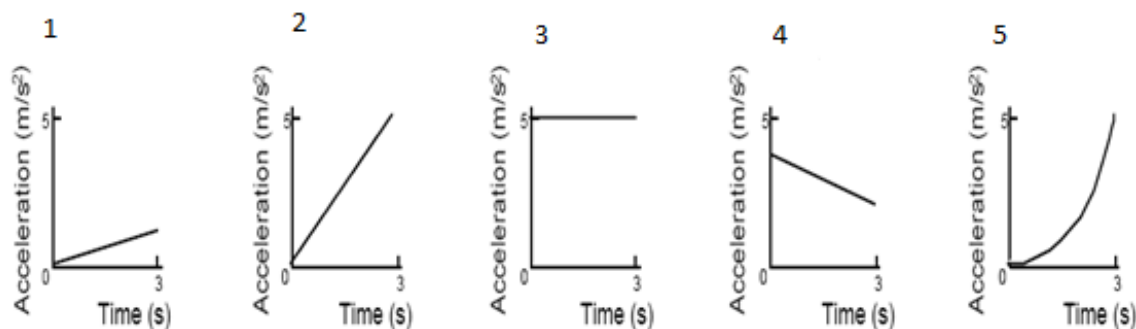


1. (A)
2. (B)
3. (C)
4. (D)
5. (E)

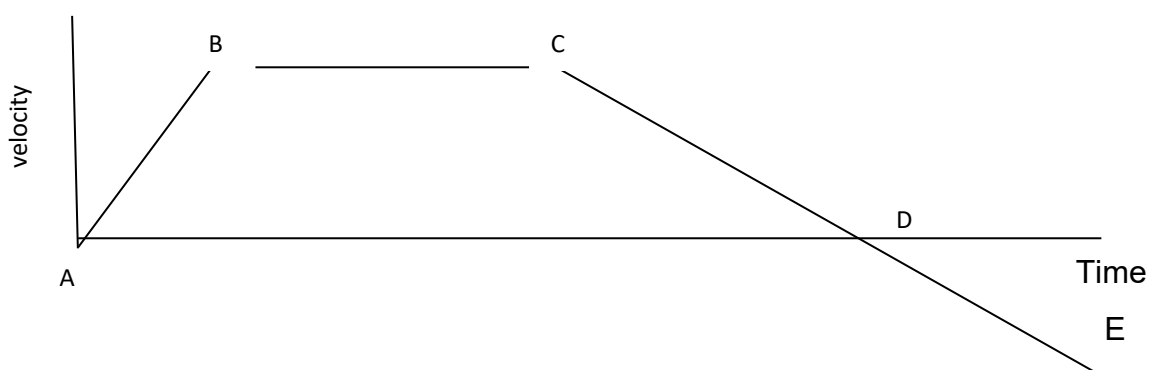
C2. An object starts from rest and undergoes a positive, constant acceleration for ten seconds. It then continues with a constant velocity. Which of the following graphs correctly describes this motion?



C3. Five objects move according to the following acceleration versus time graphs. Which has the smallest change in velocity during the three second interval?



C4. The figure below shows a velocity-time graph of an object's motion.



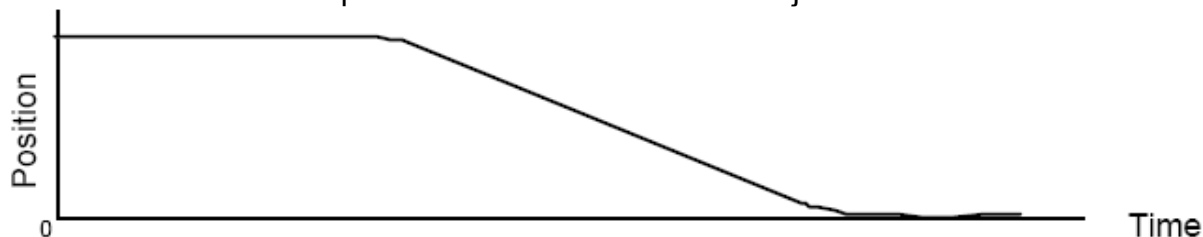
C4.1. Where is the acceleration negative?

- 1 AB
- 2 BC
- 3 CD and DE
- 4 CD only
- 5 DE only

C4.2. Where is the gradient negative?

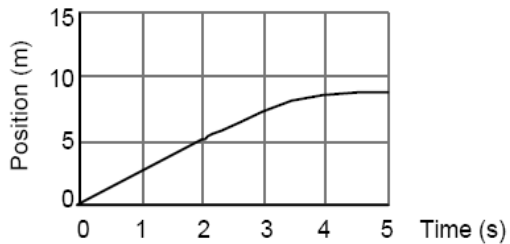
- 1 AB
- 2 BC
- 3 CD and DE
- 4 CD only
- 5 DE only

C5. The Figure below shows a position-time graph of an object's motion. Which sentence is a correct interpretation of the motion of the object?



- 1 The object rolls along a flat surface. Then it rolls forward down a hill, and then finally stops.
- 2 The object doesn't move at first. Then it rolls forward down a hill and finally stops.
- 3 The object is moving at constant velocity. Then it slows down and stops.
- 4 The object doesn't move at first. Then it moves backwards and then finally stops.
- 5 The object moves along a flat area, moves backwards down a hill, and then it keeps moving.

C6. The position-time graph below shows the straight-line motion of an object. Answer the following questions:



C6.1. The position at the 2 second point in the position-time graph is most nearly:

- 1 0.4 m
- 2 2.0 m
- 3 2.5 m
- 4 5.0 m
- 5 9.0 m

C6.2. The velocity at the 2 second point in the position-time graph is most nearly:

- 1 0.4 m/s
- 2 2.0 m/s
- 3 2.5 m/s
- 4 5.0 m/s
- 5 10.0 m/s

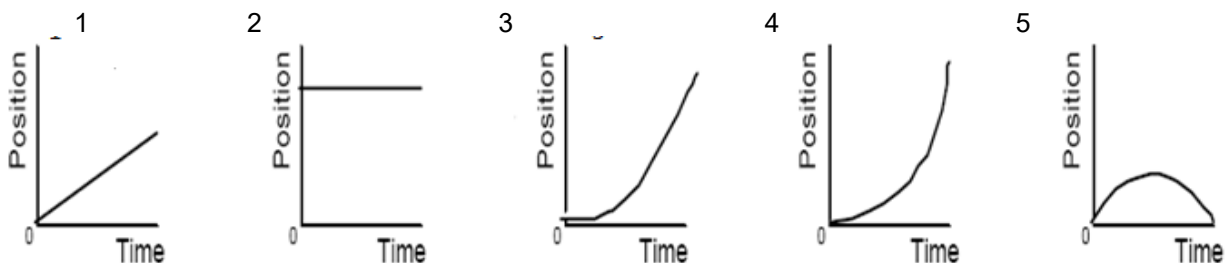
C6.3. The position at the 5 second point in the position-time graph is most nearly:

- 1 0.0 m
- 2 0.56 m
- 3 1.8 m
- 4 5.0 m
- 5 9.0 m

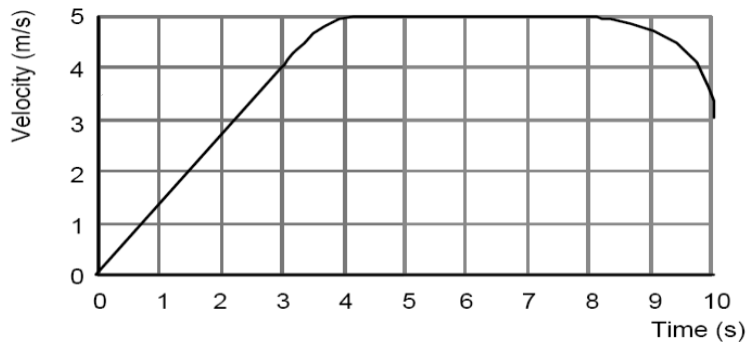
C6.4. The velocity at the 5 second point in the position-time graph is most nearly:

- 1 0.0 m/s
- 2 0.56 m/s
- 3 1.8 m/s
- 4 5.0 m/s
- 5 9.0 m/s

C7. Position versus time graphs for five objects are shown below. All axes have the same scale. Which object has the highest instantaneous velocity in the interval shown?



C8. An elevator moves from the basement to the tenth floor of a building. The elevator moves as shown in the velocity-time graph below.



C8.1. From 4 to 8 seconds the elevator:

- 1 Stands still.
- 2 Moves with constant velocity.
- 3 Moves with increasing velocity.
- 4 Accelerates uniformly.

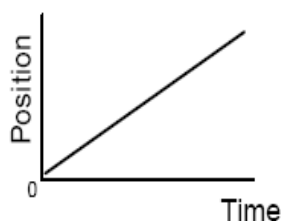
C8.2. How far does it move during the first three seconds of motion?

- 1 0.75 m
- 2 1.33 m
- 3 4.0 m
- 4 6.0 m
- 5 12.0 m

C8.3. What is its acceleration during the first three seconds?

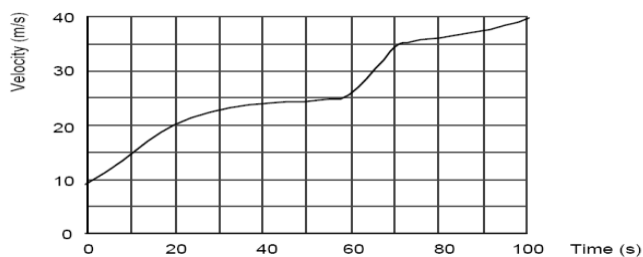
- 1 0.75 m/s^2
- 2 1.33 m/s^2
- 3 4.0 m/s^2
- 4 6.0 m/s^2
- 5 12.0 m/s^2

C9. Below is a graph of an object's motion. Which sentence is the best interpretation of the motion?



- 1 The object is moving with a constant, non-zero acceleration.
- 2 The object does not move.
- 3 The object is moving with a uniformly increasing velocity.
- 4 The object is moving with a constant velocity.
- 5 The object is moving with a uniformly increasing acceleration.

C10. The motion of an object traveling in a straight line is represented by the following graph.



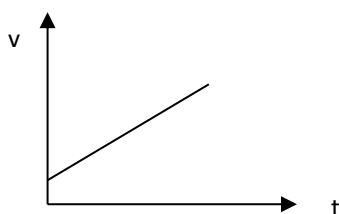
C10.1. At time = 65 s, the magnitude of the instantaneous acceleration of the object was most nearly:

- 1 +2 m/s²
- 2 +1 m/s²
- 3 +30 m/s²
- 4 +9.8 m/s²
- 5 +34 m/s²

C10.2. The graph shows that for the three parts of the motion. Which set best describes the object's motion?

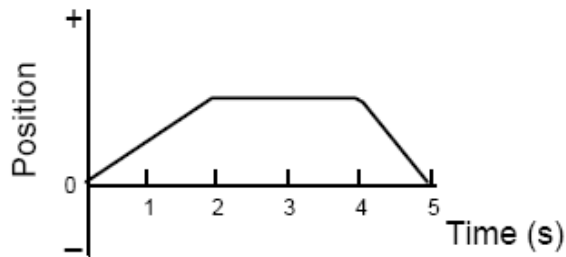
	0 to 60 seconds	60 to 70 seconds	70 to 100 seconds
1	Acceleration decreases	Acceleration remains constant	Acceleration increases
2	Velocity decreases	Velocity remains constant	Velocity increases
3	Acceleration increases	Acceleration increases	Acceleration increases
4	Velocity increases	Velocity remains constant	Velocity decreases
5	Acceleration increases	Acceleration remains constant	Acceleration decreases

C11. Which one of the following equations correctly gives the equation for the line graph below?

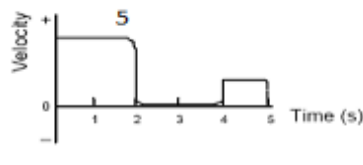
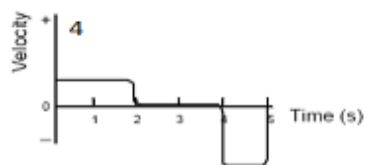
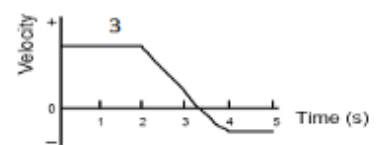
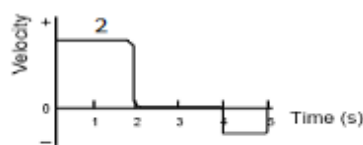
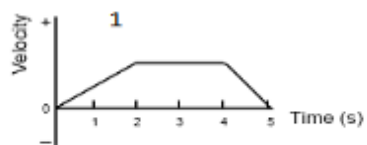


- 1 $v = at$
- 2 $v = \frac{\Delta s}{\Delta t}$
- 3 $v = u + at, u \neq 0$
- 4 $v^2 = u^2 + 2as, u \neq 0$

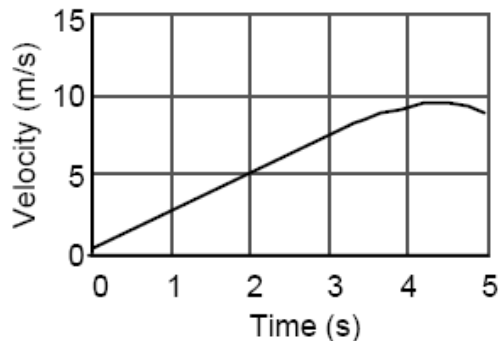
C12. The following is a position-time graph for an object during a 5 s time interval.



Which one of the following graphs of velocity versus time would best represent the object's motion during the same time interval?

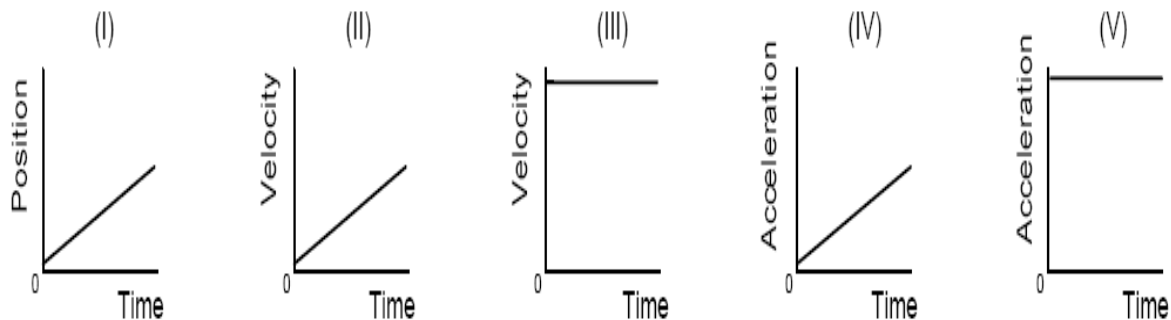


C13. If you wanted to know the distance covered during the interval from $t = 0$ s to $t = 2$ s, from the graph below you would:



- 1 Read 5 directly off the vertical axis.
- 2 Find the area between that line segment and the time axis by calculating $(5 \times 2)/2$.
- 3 Find the slope of that line segment by dividing 5 by 2.
- 4 Find the slope of that line segment by dividing 15 by 5.
5. Not enough information to answer.

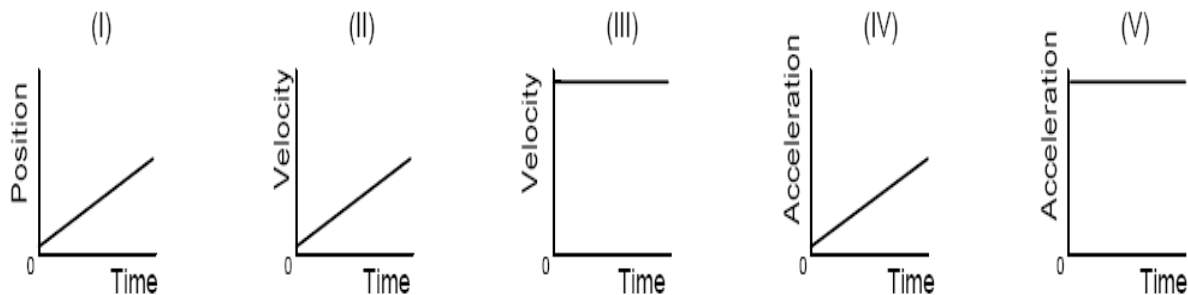
C14. Consider the following graphs, noting the different axes:



Which of these represent(s) motion at constant velocity?

- 1 I, II, and IV
- 2 I and III
- 3 III and V
- 4 IV only
- 5 V only

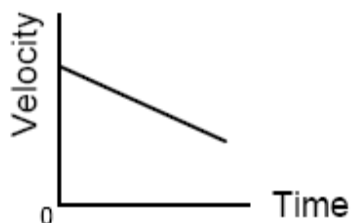
C15. Consider the following graphs, noting the different axes:



Which of these represent(s) motion at constant, non-zero acceleration?

- 1 I, II, and IV
- 2 I and III
- 3 II and V
- 4 IV only
- 5 V only

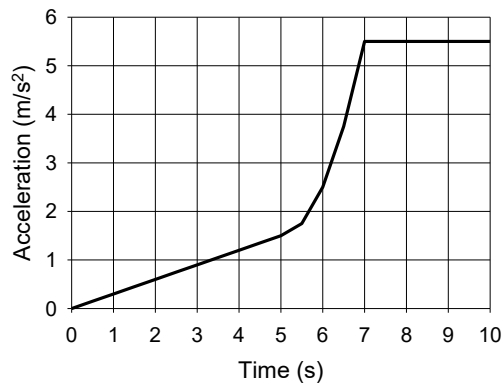
C16. Below is a velocity-time graph of an object's motion.



Which sentence is the best interpretation?

- 1 The object is moving with a constant acceleration.
- 2 The object is moving with a uniformly decreasing acceleration.
- 3 The object is moving with a uniformly increasing velocity.
- 4 The object is moving at a constant velocity.
- 5 The object does not move.

C17. The acceleration-time graph below represents the motion of an object travelling in a straight line. Answer the following questions.



C17.1. What is the change in velocity of the object from 0 seconds to 5 seconds?

- 1 1.5 m/s
- 2 5 m/s
- 3 3.33 m/s
- 4 3.75 m/s
- 5 7.5 m/s

C17.2. What is the change in velocity of the object from 7 seconds to 10 seconds?

- 1 5.5 m/s
- 2 16.5 m/s
- 3 1.833 m/s
- 4 0.545 m/s
- 5 55.0 m/s

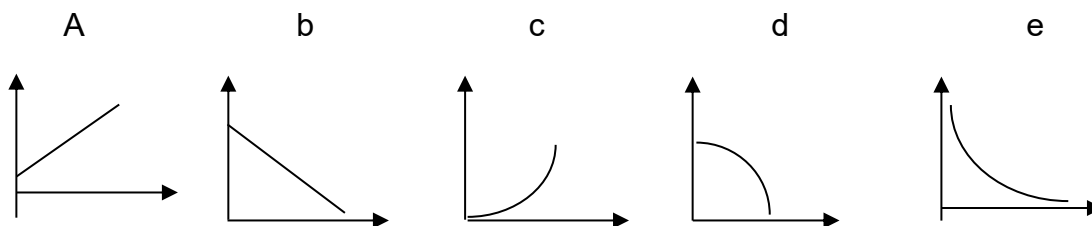
C18. The area under a velocity-time graph represents.

- 1 acceleration
- 2 change in acceleration.
- 3 speed
- 4 change in velocity.
- 5 displacement

C19. Displacement can be obtained from the:

- 1 gradient of an acceleration-time graph
- 2 gradient of a velocity-time graph
- 3 area under an acceleration-time graph
- 4 area under a velocity-time graph

C20. Choose the answers to questions below from the following graph forms.



C20.1. What is the form of the v versus t graph if $v = u + at$ is plotted with u and a positive constant?

- 1 a
- 2 b
- 3 c
- 4 d
- 5 e

C20.2. What is the form of the s versus t graph if $s = ut + \frac{1}{2}at^2$ is plotted with u and a positive constant?

- 1 a
- 2 b
- 3 c
- 4 d
- 5 e

C20.3. What is the form of the v - t graph if $v = \frac{s}{t}$ is plotted with s a positive constant?

- 1 a
- 2 b
- 3 c
- 4 d
- 5 e

C21. An object moves with a constant velocity of 6 m/s. Which one of the following statements is true?

- 1 The acceleration of the object is constant and 6 m/s².
- 2 The object undergoes a displacement of 6 m in every second.
- 3 The object does not necessarily travel in a straight line.
- 4 The velocity-time graph of the motion is a straight line through the origin.

C22. Starting from rest, an object is accelerated at 4 m/s^2 in a straight line. Answer the following questions.

C22.1. Which statement accurately describes the motion of the object?

- 1 The object travels 4 meters during each second.
- 2 The object travels 4 meters during the first second only.
- 3 The speed of the object increases by 4 m/s during each second.
- 4 The acceleration of the object increases by 4 m/s^2 during each second.
- 5 The final velocity of the object will be proportional to the distance that the object covers.

C22.2. How far has the object travelled after 10 seconds?

- 1 20 m
- 2 40 m
- 3 100 m
- 4 200 m
- 5 400 m

C22.3. What is the speed of the particle after it has travelled 8 m?

- 1 4 m/s
- 2 8 m/s
- 3 32 m/s
- 4 64 m/s
- 5 100 m/s

F1.

For office use only	
Total E1+F1 score	

D1.

For office use only	
Total Kinematics graphs score	

Thank you for your cooperation.

Appendix F – Educators’ questionnaire

Educators’ Questionnaire

INFORMED CONSENT BY EDUCATOR

I, the undersigned teacher, understand that participating in this research project is completely voluntary and no pressure may be placed on me to participate. I understand that it is not a test and will not influence my work and or my employer. I hereby give permission that the results may be used for research purposes.

.....

Signature - Educator

Date

Section A

1. How old are you?

*Check **one** box only.*

- 1: under 25
- 2: 25-29
- 3: 30-39
- 4: 40-49
- 5: 50-59
- 6: 60 or more

2A Are you female or male?

*Check **one** box only.*

- 1: female.....
- 2: male

2B. Which best describes you?

*Check **one** box only.*

- 1: White.....
- 2: Black.....
- 3: Indian
- 4: Coloured.....

5: Other (specify) _____

3 Type of school

- 1: Urban (private or former Model C)
- 2: Semi-urban (town but not former Model C)
- 3: Township
- 4: Village
- 5: Farm

4A. By the end of this school year, how many years altogether will you have been teaching physics/physical science? Please round to the nearest whole number

- 1: 1 - 2 years
- 2: 3 – 4 years
- 3: 5 – 7 years
- 4: 8 - 10 years
- 5: More than 10 years

4B. How many years will you have taught mathematics?

- 1: Zero year
- 2: 1 - 2 years
- 3: 3 – 5 years
- 4: 6 – 8 years
- 5: 9 years and more

4C. How long do you plan to continue teaching physics?

*Fill in **one** circle only.*

- 1: I plan to continue teaching as long as I can
- 2: I plan to continue teaching until the opportunity for a better job in education comes along
- 3: I plan to continue teaching for a while but probably will leave the field of education
- 4: I am undecided currently

4D Do you need to teach mathematics also in order, or think your mathematics knowledge help you, to teach physics efficiently and effectively?

1: No

2: To some extent

3: A lot

Section B

5. How well confident do you feel you are to teach the following topics?

In a scale of 1 – 3 where 1-

- 1 - Not well confident
- 2 - Somewhat confident
- 3- Very well confident

- A. Mechanics
- B. Electricity and Magnetism
- C. Heat and Temperature
- D. Atomic and Nuclear Physics

6 In your school, how often do you have the following types of interactions with other teachers?

In a scale of 1 – 4, where

1: Daily or almost daily

2: 1-3 times per week

3: 2 or 3 times per month

4: Never or almost never

- a) Discussions about how to teach a particular concept
- b) Working on preparing instructional materials
- c) Visits to another teacher's classroom to observe his/her teaching
- d) Informal observations of my classroom by another teacher

7 In the past two years, have you participated in professional development in any of the following?

Answer yes or, where

1: No

2: Yes

- a) Physics content
- b) Physics pedagogy/instruction
- c) Physics curriculum
- d) Integrating information technology into physics
- e) Improving learners' critical thinking or inquiry skills
- f) Physics assessment

8 In your current school, how severe is each problem?

In a scale of 1 - 3

1: Serious problem

2: Minor problem

3: Not a problem

- a) The school building needs significant repair
- b) Classrooms are overcrowded
- c) Teachers do not have adequate workspace outside their classroom
- d) Materials are not available to conduct physics experiments or investigations

9 How would you characterize each of the following within your school?

In a scale of 1 – 5, where

1: Very low

2: Low

3: Medium

4: High

5: Very high

- a) Teachers' job satisfaction
- b) Teachers' understanding of the school's curricular goals
- c) Teachers' degree of success in implementing the school's curriculum
- d) Teachers' expectations for student achievement
- e) Support for teachers' professional development
- f) Parental support for student achievement
- g) Parental involvement in school activities
- h) Learners' regard for school property
- i) Learners' desire to do well in school

10 How many learners are in the physics class?

Write in the number of learners.

11A How many periods (and minutes per period) per week do you teach physics per class?

*Write in the number of **minutes** per week.*

Please convert the number of instructional hours or periods into minutes.

11B How many physics classes, not periods, do you have per week?

Write in the number of learners.

12 How many minutes per week do you usually spend preparing to teach physics in class>?

*Write in the number of **minutes** per week.*

13A. Do you use a textbook as the basis for instruction in teaching physics to the physics class?

1: No

2: Yes

*Fill in **one** circle only.*

13B. Does each student have his or her own textbook?

1: No

2: Yes

*Fill in **one** circle only.*

13C. How often do you require learners to do the following?

*Fill in **one** circle for each row.*

1: Never

2: Some lessons

3: About half the lessons

4: Every or almost every lesson

- a) Do problems or exercises from their textbooks
- b) Read the textbook examples of how to do problems or exercises
- c) Read about physics theory from their textbooks

14 In a typical week of physics lessons, what percentage of time do learners spend on each of the following activities?

Write in the percent.

The total should add to 100%

- a) Teaching new material to the whole class _____%
- b) Learners working problems on their own or with other learners _____%
- c) Reviewing and summarizing what has been taught for the whole class _____%
- d) Reviewing homework _____%
- e) Re-teaching and clarifying content/procedures for the whole class _____%
- f) Oral or written tests or quizzes _____%
- g) Classroom management tasks not related to the lesson's content/purpose (e.g., interruptions and keeping order) _____%
- h) Other activities _____%

15 In teaching physics to the learners in the physics class, how often do you usually ask them to do the following?

*Fill in **one** circle for each row.*

1: Never

2: Some lessons

3: About half the lessons

4: Every or almost every lesson

- a) Watch me demonstrate an experiment or investigation
- b) Conduct experiments or investigations
- c) Use laws and formulas of physics to solve routine problems
- d) Give explanations about something they are studying
- e) Relate what they are learning in physics to their daily lives
- f) Have learners memorize formulas and procedures
- g) Read their textbooks or other resource materials

16 In your view, to what extent do the following limit how you teach the physics class?

*Fill in **one** circle for each row.*

1: A lot

2: Some

3: A little

4: Not at all

5: Learners

- a) Learners with different academic abilities
- b) Learners who come from a wide range of backgrounds (e.g., economic, language)
- c) Learners with special needs (e.g., hearing, vision, speech impairment, physical or learning disabilities)
- d) Uninterested learners
- e) Disruptive learners
- n) High student/teacher ratio

17 How often do learners in the physics class use calculators in their physics lessons for the following activities?

*Fill in **one** circle for each row.*

1: Never

2: Some lessons

3: About half the lessons

4: Every or almost every lesson

- a) Doing scientific procedures or experiments
- b) Modelling and simulations
- c) Solving equations
- d) Processing and analysing data

18 How often do learners in the physics class use algebraic knowledge or skills in their physics lessons for the following activities?

*Fill in **one** circle for each row.*

1: Never

2: Some lessons

3: About half the lessons

3: Every or almost every lesson

- a) Doing scientific procedures or experiments
- b) Processing and analysing data
- c) Plotting a graph
- d) interpretation of graph and or results
- e) Solving equations

19 How often do you assign the following kinds of physics homework to the physics class? Fill in *one* circle for each row.

1: Never or almost never

2: Sometimes

3: Always or almost always

- a) Doing problem/question sets
- b) Reading the textbook
- c) Memorizing formulas and procedures
- d) Gathering, analysing, and reporting data
- e) Finding one or more applications of the content covered
- f) Working on projects

20 How much emphasis do you place on the following sources to monitor learners' progress in physics?

*Fill in **one** circle for each row.*

1: No emphasis

2: Little emphasis

3: Some emphasis

4: Major emphasis

- a) Classroom tests (e.g., teacher-made, or textbook tests)
- b) Informal assessment
- c) <Other test>

21A How often do you assign the following kinds of physics homework to the physics class?

*Fill in **one** circle for each row.*

1: Never or almost never

2: Sometimes

3: Always or almost always

- a) Doing problem/question sets
- b) Reading the textbook
- c) Memorizing formulas and procedures
- d) Gathering, analysing, and reporting data
- e) Finding one or more applications of the content covered
- f) Working on projects

21B How often do you include the following types of questions in your physics tests or examinations?

*Fill in **one** circle for each row.*

1: Never or almost never

2: Sometimes

3: Always or almost always

- a) Questions based on knowing facts and concepts
- b) Questions based on the application of knowledge and understanding
- c) Questions involving developing hypotheses and designing scientific investigations
- d) Questions requiring explanations or justifications

22 How much emphasis do you place on the following sources to monitor learners' progress in physics? Fill in **one circle for each row.**

1: No emphasis

2: Little emphasis

3: Some emphasis

4: Major emphasis

- a) Classroom tests (e.g., teacher-made, or textbook tests)
- b) Informal assessment
- c) Other test

23A. What item formats do you typically use in your physics tests or examinations?

In a scale of 1 – 4, where

- 1: Only constructed response
- 2: Mostly constructed response
- 3: About half constructed response and half objective
- 4: Mostly objective
- 5: Only objective

23B. How often do your physics tests or examinations include a practical examination or laboratory problems? Fill in *one* circle only.

- 1: Always or almost always
- 2: Sometimes
- 3: Never or almost never

25 APPROXIMATELY how many hours per week do you normally spend on each of the following activities outside the formal school day?

Check one box in each row.

1: None

2: Less than 1 hour

3: 1 - 2 hours

4: 3 - 4 hours

5: More than 4 hours

- a) preparing or grading student tests or exams
- b) reading and grading other student work
- c) planning lessons by yourself
- d) meeting with learners outside of classroom time (e.g., tutoring, guidance)
- e) meeting with parents
- f) professional reading and development activity (e.g., seminars, conferences, etc)
- g) keeping learners' records up to date
- h) administrative tasks including staff meetings (e.g., photocopying, displaying learners' work).
- i) other

26 APPROXIMATELY how many hours per week do you normally spend on your teaching activities altogether (include time spent in and out of school)? Please round to the nearest whole hour.

1: None

2: Less than 1 hour

3: 1 - 2 hours

4: 3 - 4 hours

5: More than 4 hours

27 To be good at science at school, how important do you think it is for learners to...

1: Not important

2: Somewhat important

3: Very important

- a) remember formulas and procedures
- b) think in a sequential and procedural manner
- c) understand science concepts, principles, and strategies.....
- d) be able to think creatively
- e) understand how science is used in the real world
- f) be able to provide reasons to support their conclusions

28 How much influence do you have on each of the following...

*Check **one** box in **each** row.*

1: None

2: Little

3: Some

4: A lot

- a) subject matter to be taught
- b) specific textbooks to be used
- c) the amount of money to be spent on supplies
- d) what supplies are purchased.....

29. About how often do you have meetings with other teachers in your subject area to discuss and plan curriculum or teaching approaches?

*Check **one** box only.*

- 1: never.....
- 2: once or twice a year
- 3: every other month
- 4: once a month
- 5: once a week
- 6: two or three times a week
- 7: almost every day

30 To what extent do you agree or disagree with each of the following statements?

Check one box in each row.

1: Disagree

2: Strongly disagree

3: Agree

4: Strongly agree

- a) Science is primarily an abstract subject.
- b) Science is primarily a formal way of representing the real world.
- c) Science is primarily a practical and structured guide for addressing real situations.
- d) Some learners have a natural talent for science and others do not.....
- e) It is important for teachers to give learners prescriptive and sequential directions for doing science experiments.
- f) Focusing on rules is a bad idea. It gives learners the impression that the sciences (physics, chemistry, biology, and earth science) are a set of procedures to be memorized
- g) If learners get into debates in class about ideas or procedures covering the sciences, it can harm their learning.
- h) Learners see a science task as the same task when it is represented in two different ways (picture, concrete material, symbol set, etc.).
- i) A liking for and understanding of learners are essential for teaching science.

31 How well prepared do you feel you are to teach... Check one box in each row.

I do Not Very teach these well Somewhat well topics prepared.

- a) Mechanics?
- b) Kinematics?
- c) Measurements and Dimensional analysis

32 What is the highest level of formal education you have completed? Check one box only.

- 1: Did not complete secondary school
- 2: Secondary school only
- 3: Diploma
- 4: Bachelor's degree or equivalent
- 5: Honours or B. Tech.
- 6: Master's degree
- 7: PhD

33A Do you have a teacher training certificate/qualification?

Check **one** box only. **Yes No**

33B How many years of pre-service teacher training have you had?

Please round to the nearest whole number.

(Write in 0 (zero), if you have not had any teacher training.)

33C If you have done pre-service teacher training (teaching practice), did you begin this training in high school (FET Phase)?

1: **Yes**

2: **No**

34 In your preservice science teacher training, what were your major subjects or was your main area of study?

1: I do not have a bachelor's degree or equivalent.

(Check the box and skip to the next question.)

Check **one** box in **each** row.

2: **Yes**

3: **No**

- a) Physics
- b) Chemistry
- c) Physical Sciences
- d) Mathematics
- e) Physical Science Methodology
- f) Mathematics Methodology
- g) Education

Section C

35 Do learning and problem solving in kinematics graphs require mathematics knowledge and skills?

36 Are learners able to relate terminologies or symbols in kinematics with variables in algebra/mathematics?

37 What or which concepts in mathematics are the required skills in the learning and problem solving of kinematics graphs?

38A In teaching kinematics to your learners in class>, how often do you usually emphasize and ask them to do the following?

Fill in one circle for each row.

1: Never

2: Some lessons

3: About half the lessons

4: Every or almost every lesson

- a) Describing Motion with Words
- b) Describing Motion with Diagrams
- c) The Meaning of Shape for a p-t Graph
- d) Meaning of Slope for a p-t Graph
- e) Determining the Slope on a p-t Graph
- f) Meaning of Shape for a v-t Graph
- g) Meaning of Slope for a v-t Graph
- h) Relating the Shape to the Motion
- i) Determining the Slope on a v-t Graph
- j) Determining the Area on a v-t Graph
- k) Construct an informative diagram of the physical situation.
- l) Identify and list the given information in variable form.
- m) Identify and list the unknown information in variable form.
- n) Identify and list the equation that will be used to determine unknown information from known information.
- o) Substitute known values into the equation and use appropriate algebraic steps to solve for the unknown information.
- p) Check your answer to ensure that it is reasonable and mathematically correct.

38B In general, and according to your experience, what is your learners' performance in the above principles or concepts?

1: Poor

2: Below average

3: Average

4: Good

5: Very Good

Appendix G –Educators’ Qualitative Research Interview questions

Qualitative Research Interview questions

Dear colleagues

Kindly assist by completing the following questions. The response is anonymous and your name or that of the school will not be disclosed but the information will be used for research purpose and to see how the study can enhance the teaching of kinematics (physics) using algebra (mathematics) to enhance the learners’ performance in kinematics (physics) and to support other fellow teachers.

Kindly note that permission has been sought and granted from FS DBE and CUT to conduct this study.

1. What is the importance of learning and or teaching graphs?
2. How does graphs in algebra relate with graphs in kinematics?
3. Explain how will you obtain average velocity and instantaneous velocity in a velocity-time graph and in a displacement-time graphs?
4. How do you integrate algebraic graph skill or knowledge in the teaching of kinematics graphs?
5. What problems do learners face or encounter in the drawing and interpretation of graphs in algebra and kinematics?
6. How do learners perceive the knowledge and skills of graphs in algebra to solve graphs in kinematics?
7. What skills or measures or pre-cautions do physics teachers need to apply in the teaching of kinematics learners?
8. What makes learners find algebra graphs difficult or make them perform poorly in algebraic graphs?
9. What makes learners find kinematics graphs difficult or make them perform poorly in kinematics graphs?
10. What are the challenges physics teachers find in the teaching of algebraic and kinematics graphs?
11. Can you describe the attitudes and approaches to teaching of algebraic and kinematics graphs from the other people working with you (in physics and or mathematics teaching) in general, not only colleagues or seniors in your school? What support do you get and give to one another?
12. You were once a learner, teacher trainee (student teacher) and later a teacher. What observations did you make in your progression?

Your kind and urgent assistance and support will be highly appreciated. I will appreciate it if I can get your response on or before Friday 26 May 2023. Take a picture/photo of your responses and whatsapp it to me.

Thank you in advance for your assistance and support.

Kind regards



.....
Mr Happy Phage – Lecturer at CUT
Mobile and whatsapp number: 0823389259

Appendix H – Parent/guardian and learner consent forms (research participants)

PARENT/GUARDIN CONSENT FORMS (RESEARCH PARTICIPANTS)

Statement of informed consent [For learner's questionnaire]

This form requests your permission for your child to complete a questionnaire related to the research in teaching and learning graphs in algebra and kinematics. If you agree to your child's participation, please complete, and sign the form below.

- Do you understand the nature of the research sufficiently well to make a free informed decision on behalf of your child? Yes, or No?
- Are you satisfied that the circumstances in which the research is being conducted provide for the physical, emotional, and psychological safety of your child?

Yes, or No?

I, (Print name), agree that:

1. I have read and understood the enclosed information sheet explaining the research and its purpose and am allowing my child to complete the questionnaire about the teaching and learning of algebra and kinematics in the FET Physical Science curriculum.
2. I understand that all identifiable information obtained will be treated as strictly confidential and that all research data will be securely stored.
3. I agree that information collected during the study may be used in publications if involvement of the school and my child cannot be identified.
4. Any questions that I have asked to have been answered to my satisfaction.
5. I agree to allow my child to participate in this research study and understand that I may withdraw my child at any time without any consequences.

I give my permission for..... (Print child's name) to participate in this research study.

Signed at (Place)_____

Signature of parent/guardian

Date

Statement by child:

I have discussed participation with my parent/guardian, understand what participation involves, and agree to participate in this study: Name of child:

Signed at (Place)_____

Signature of learner

Date

Appendix I – Request for permission to principals



Mr. Itumeleng Phage
Department of Mathematics, Science and Technology Education
Faculty of Humanities
Tel: +27 51 507 3827 | Mobile: +27 82 338 9259 | E-mail: iphage@cut.ac.za or
phageh@gmail.com
Central University of Technology, Free State (CUT)
Private Bag X20539, Bloemfontein, 9300, South Africa

REIMAGINE CUT | CO-CREATING VISION 2030
our people, our voices

20th Feb 2020

To: The Principal

High/Secondary School

Dear Sir/Madam,

Re: REQUEST FOR PERMISSION TO CONDUCT THE RESEARCH

My name is ITUMELENG BARNARD PHAGE (Mr). I am registered for Doctor of Education in Physical Science (D.Ed. in Physical Science) at Central University of Technology, Free State (CUT, FS) with student number: 217011797. I am currently employed by CUT, FS, in the Department of Mathematics, Science and Technology Education (MSTE).

Title of my study: Physical sciences teachers' and learners' perceptions on the content knowledge and conceptual understanding of graphs in algebra and kinematics

Supervisor: Dr R Bhagwande (CUT, FS) – rguta@cut.ac.za

Co-Supervisor: Prof P Sepeng (CUT, FS) – psepeng@cut.ac.za

I hereby kindly request your permission to conduct the data collection exercise at your school with your assistance and blessing. Data collection will be conducted through the administration and responding to a questionnaire and its follow-up interviews with physical science educators. Data will be collected outside teaching time, i.e., after school hours, between 14:00 and 15:00, Monday to Friday from 24 August 2020 to 30 September 2020 for questionnaires and from 18 January 2021 to 05 February 2021 for interviews. Only one day for questionnaires and one day for interviews per school. Exact or specific dates for visit to the school will be communicated to the school prior hand.

The information will be held and used on a strict, confidential, and anonymous basis. The purpose of this research is to investigate the approaches for teaching and learning of kinematics using algebraic knowledge and to recommend improved practices or model. The consent of the

selected respondents (teachers and learners) will be secured, since their participation will be voluntary. I commit to abide by any conditions that you may elect to set for me. Ethical approval for this undertaking is thus accorded by Free State Department of Education (FSDoE) and the CUT, FS.

Thank you in advance for your assistance.

Yours faithfully,



Itumeleng Phage - Researcher

24 August 2020

Date

Appendix J1 –

LETTER OF APPROVAL FROM SCHOOL PRINCIPAL

Dear Mr. I Phage

Re: Permission conduct study in the school

I, principal of, hereby grant you permission conduct and collect data with physical science teachers and Grade 11 of my school to participate in the research for your further studies.

Best wishes

Signed at (Place) _____

Principal

Date

School Stamp

Appendix J2 – Approval by principal

LETTER OF APPROVAL FROM SCHOOL PRINCIPAL

Dear Mr. I Phage

Re: Permission conduct study in the school

I, SEEKOEI F.A principal of Albertina Sisulu
herby grant you permission conduct and collect data with physical science teachers and
Grade 11 learners of my school to participate in the research for your further studies.

Best wishes

Signed at (Place) Edenburg


Principal

17/08/2020
Date

School Stamp

THE FREE STATE DEPARTMENT
OF EDUCATION
KHARIEP DISTRICT

17-08-2020

**ALBERTINA SISULU
SECONDARY SCHOOL**
P.O. BOX 56 • EDENBURG 9908
TEL: 081 743 1859

Appendix K1 - Educators' Consent form [Questionnaire]

Educators' Consent form [Questionnaire]

I hereby give consent that I have discussed the research study with Mr. Itumeleng Phage, and I fully understand the purpose and extent of the research, and accept that my involvement is strictly confidential, i.e., will not disclose my name or that of the school, namely:

- Completing questionnaires in relation to teaching and learning of graphs in algebra and kinematics

I give my approval to be involved in the study, on the conditions outlined below:

- I can ask Mr Itumeleng Phage any questions about the study.
- There will be no reports written in which the school or I could be identified.
- I can withdraw from being involved at any stage, without having to give any reasons.

Signed at (Place) _____

Signature

Date

Appendix K2 - Educators' Consent form [Interviews]

Educators' Consent form (Interview)

I hereby give consent that I have discussed the research study with Mr. Itumeleng Phage, and I fully understand the purpose and extent of the research, and accept that my involvement is strictly confidential, will not disclose my name or that of the school, namely:

- being interviewed (and or audiotaped) in relation to teaching and learning graphs in algebra and kinematics.

I give my approval to be involved in the study, on the conditions outlined below:

- I can ask Mr Itumeleng Phage any questions about the study.
- There will be no reports written in which the school or I could be identified.
- I can withdraw from being involved at any stage, without having to give any reasons.

Signed at (Place) _____

Signature

Date