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INVESTIGATING GRADE 10 PHYSICAL SCIENCES TEACHERS' BELIEFS AND ATTITUDE ABOUT INQUIRY-BASED TEACHING AND LEARNING

By

Manzini Samson Hlatshwayo

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SUPERVISOR: Prof U Ramnarain

CO-SUPERVISOR: Prof J de Beer

OCTOBER 2015

DECLARATION

I Manzini Samson Hlatshwayo declare that the work contained in this dissertation is my own and all the sources I have used or quoted have been indicated and acknowledged by means of references.

I also declare that I have not previously submitted for this dissertation or any part of it to any university in order to obtain a degree.

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Signature: ___________________________

(Manzini Samson Hlatshwayo)

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ABSTRACT

Inquiry has for decades been the prominent and central theme of science curriculum improvement, and inquiry has been used to characterise good science teaching and learning (Anderson, 2002; Anderson, 2007). However science curricula have only recently started to explicitly prescribe inquiry as a pedagogical strategy. In the South African Physical Sciences Curriculum it was only in the 2007 National Curriculum Statement Grade 10–12 Physical Sciences Subject Assessment Guidelines where the use of scientific inquiry was explicitly stated as the major focus of Physical Sciences (Department of Basic Education, 2007).

While science reform documents internationally, including the South African Physical Sciences Curriculum and Assessment Policy Statement, promote inquiry as a pedagogical strategy that can assist learners to fully understand science, the use of inquiry as a strategy by teachers continues to be a challenge. Emanating from the fact that inquiry as a pedagogical strategy has only recently been explicitly stated in the South African Sciences Curriculum, not much research has been done in South Africa to evaluate teachers' beliefs and attitudes about inquiry or to evaluate the implementation of inquiry in South African sciences classrooms. There is therefore a need to evaluate and documents factors influencing teachers' choices of pedagogical strategies and the extent of the implementation of inquiry by teachers in South African science classrooms.

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This study investigated Grade 10 Physical Sciences teachers' beliefs and attitude about inquiry-based teaching and learning. The objectives of this study were first to use a validated instrument to describe and measure Grade 10 Physical Sciences teachers' belief and attitudes about inquiry-based teaching and learning, then to determine the extent to which inquiry is being implemented in their classrooms, and finally to investigate the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices.

The study used a sequential mixed methods design, where quantitative data was collected first by distributing the questionnaire to all the Grade 10 Physical Sciences teachers within two education circuits Badplaas and Mashishila. This was followed by the collection of qualitative data through the use of classroom observations of three of the teachers who participated in the questionnaire, conducting interviews with the three teachers and analysing documents such as learners' classwork books and teachers' lesson plans. The questionnaire which was developed during the European Union funded project entitled "Promoting Inquiry-based learning in Mathematics and Science Education" (PRIMAS), tested teachers on four constructs: teachers' attitudes about inquiry as a pedagogy, teachers' beliefs and readiness to use inquiry as a pedagogy, teachers' current practices and the extent to which teachers employ inquiry in their teaching practices, and the extent to which teachers engage learners in inquiry-based learning activities (PRIMAS, 2011). Teachers' responses were analysed quantitatively by calculating the averages of each of the items in the questionnaire. The quantitative results were then compared with the qualitative data analysis. Classroom observations were analysed using the Reformed Teacher Observation protocol (RTOP).

It was found that teachers view inquiry-based teaching and learning as an instructional strategy that has the potential to address many of the challenges in the teaching and learning of Physical Sciences. However, there was no evidence of the implementation of inquiry-based teaching and learning in the science classrooms. All the observed lessons were highly teacher-centred. Teachers mentioned a number of challenges as the causes of difficulties in implementing inquiry in their science classrooms. The main challenge mentioned was the unavailability of adequate teaching materials.

A recommendation of this study is a long term study with a larger sample to get authoritative findings on teachers' beliefs and attitudes about inquiry-based teaching and learning. The long term study will also give answers on why teachers with favourable beliefs about inquiry-based teaching and learning continue to favour the traditional teacher-centred approach in their classrooms.

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LIST OF ACRONYMS USED IN THIS STUDY

APP	Reports on the frequency of teaching with a focus on application and to relationship to daily life
CAPS	Curriculum and Assessment Policy Statement
CEO	Chief Executive Officer
CPD	Continuing Professional Development
DBE	Department of Basic Education
EDI	Measure the frequency of discussion regarding experiments
EXE	Measures the frequency of exercise
HON	Measures the frequency of practical activities with a focus on the hands on aspects
IBL	Inquiry-based Learning

INT	Measures the frequency of learners interaction focusing on discussion
INV	Captures the frequency of investigation
MST	Mathematics Science and Technology
NRC	National Research Council
NSES	National Science Education Standards
OCEPT	Oregon Collaborative for Excellence in the Preparation of Teachers
O-TIP	Teacher Interview Protocol
POE	Predict-Observe-Explain
PRIMAS	Promoting Inquiry-based learning in Mathematics and Science Education
RTOP	Reformed Teaching Observation Protocol

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CHAPTER 1: CONCEPTUALISATION OF THE RESEARCH PROBLEM

1.1 INTRODUCTION

Preparing scientifically and technologically literate citizens is at the centre of science education, because scientific and technological literacy are necessary for coping with the requirements of modern life (Panasan & Nuangchalerm, 2010; Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013). Scientific literacy generally refers to the ability to read and understand media accounts of science and scientific issues, and involves the ability to make informed decisions on socio-scientific issues and addresses the need for citizens to actively participate and make meaningful contributions in a technologically advanced society (Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013). Achieving scientific literacy requires a broader view of science that includes three principal components: the knowledge of science, the methods of science, and the nature of science (Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013).

Scientific knowledge is the most familiar component of scientific literacy, and includes all of the scientific facts, definitions, laws, theories and concepts commonly associated with science instruction. The methods of science refer to the varied procedures that scientists use to generate scientific knowledge, and focus on basic inquiry skills, which include observing, inferring, predicting, measuring and experimenting. The nature of science addresses the characteristics of scientific knowledge and depicts science as an important way to understand and explain the experiences in the natural world, and acknowledges the values and beliefs inherent in the development of scientific knowledge (Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013).

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These three components of scientific literacy are highly interrelated and to achieve scientific literacy in science classrooms, science instructions should reflect the synergy that exists among the components (see Figure 1.1)

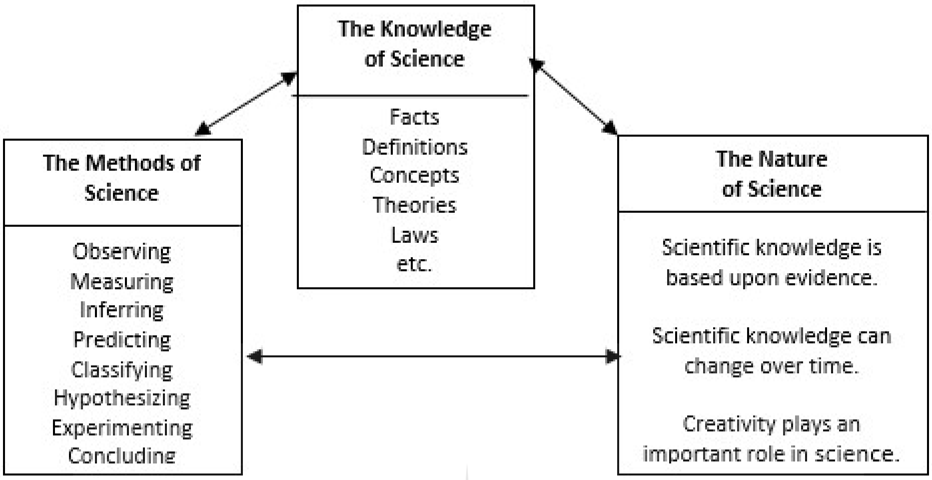

Figure 1.1 Three components of scientific literacy (**Adapted from Bell, Maeng & Peters, 2013)**

The major aim of science education in schools is therefore to produce scientifically literate learners with a well-developed scientific knowledge, who can think critically based on the nature of science (Panasan & Nuangchalerm, 2010). The South African National Curriculum Statement Grade R-12 also promotes equipping learners with knowledge, skills and values necessary for meaningful participation in society as citizens of a free country, as the main purpose of the curriculum (Department of Basic Education, 2011:4). The South African Physical Sciences Curriculum and Assessment Policy Statement (CAPS) further promotes knowledge and skills in scientific inquiry as a means through which scientifically literate citizens can be prepared (Department of Basic Education, 2011:8). Reforms in education emphasise the use of teaching strategies that will equip learners with knowledge and skills for the learners to be active participants and contributors in the development of society (Miller, 2007; Department of Basic Education, 2011; Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013).

There is, therefore, a need for alternative teaching strategies within science instruction which are aimed at teaching effectively the science content and science concepts, as compared to the traditional teacher-centred and knowledge-based teaching methods (Miller, 2007).

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Inquiry-based teaching and learning strategies which encourage an active and critical approach to teaching and learning, rather than the traditional rote and uncritical learning of given truths, is the promoted strategy (Miller, 2007; Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013). Anderson (2007) argues that current science educational practices are not up to par and there is a need to change them to include more inquiry. The National Curriculum Statement Grades 10–12 Physical Sciences Subject Assessment Guidelines put the focus of Physical Sciences on investigating physical and chemical phenomena through scientific inquiry and assessment that should focus on learners demonstrating inquiry skills (Department of Basic Education, 2007). While science education reform is a difficult and multifaceted task, within the realm of science education reform, emphasis lies heavily on the importance of scientific inquiry experiences for learners (Smolleck, Zembal-Saul & Yoder, 2006). Harwood, Hansen, and Lotter (2006) concluded that a major trend in science education reform is an emphasis towards inquiry-based learning over transmission-based instruction. Zion, Cohen, and Amir (2007) argue that engaging learners in inquiry-based learning is a cornerstone of ongoing science education reform. Although teaching and learning science as inquiry can be challenging, it is attainable and has proven benefits for learning; hence teaching science as inquiry is an important theme within educational reform (Smolleck & Mongan, 2011).

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Contrary to the traditional strategy of teaching where learners are bombarded with a great number of facts and learners' role is to memorise the given facts, inquiry-based teaching and learning offers learners an opportunity to engage with science and experience science as experienced by scientists (Sanger, 2007). Through inquiry-based teaching and learning learners are guided to construct an understanding of new information by associating it with prior knowledge in an organised and systematic way (Rooney, 2012). The essence of inquiry is the active involvement of learners, focusing on the 'why' and 'how' and less on the 'what' and this helps learners to gain a better perception of what science is and how it is practised (Zion, 2007; Rooney, 2012). Ramnarain and Kibirige (2010) argue that inquiry-based teaching and learning also contribute to the social development of the learner. Inquiry-based teaching and learning provides learners with an important experiential base to become critical consumers of science and participants in a scientifically laden culture (Abd-El-Khalick, Boujaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust & Tuan, 2004).

Despite growing consensus regarding the value of inquiry-based teaching and learning, research has found that the implementation of such a pedagogical practice continues to be a challenge for many teachers (Dillon, 2008; Smolleck & Mongan, 2011; Trautmann, MaKinster & Avery, 2004). In a study of primary school teachers in Hong Kong conducted by Chan (2010), it was found that while teachers have positive beliefs about inquiry-based teaching and learning, such beliefs have not developed into influencing their choice of pedagogical strategies, and the teachers were found to seldom use inquiry-based teaching and learning approaches in their classrooms. In a study conducted across European countries, it was found that while there is a positive orientation towards inquiry-based teaching and learning, there are significant differences in the actual use of inquiry-based teaching and learning approaches in classrooms (PRIMAS, 2011). Saad and BouJaoude (2012) state that in a study in Lebanon, teachers found that while 85% of the teachers had positive attitudes and favourable beliefs towards scientific inquiry, classroom practices of the teachers indicated that there is no consistent relationship between attitudes and beliefs, knowledge about inquiry, and practices.

Anderson (2002) has stated that teachers considering new approaches to education face many dilemmas, many of which have their origins in their beliefs and values. Chan (2010) also concluded that many of the barriers and obstacles preventing teachers from implementing inquiry-based teaching have their origins in teachers' deeply held educational beliefs and attitudes. Saad and BouJaoude (2012) also argue that one of the major barriers to implementing inquiry practices in science classrooms is teachers' beliefs about teaching, learning and classroom management.

Beliefs and attitudes teachers hold influence their perceptions and judgement, which in turn affect their choices of teaching strategies and their behaviour in the classroom (Pajares, 1992). Anderson (2002; 2007) has stated that there is a connection between teachers' beliefs and values on the one hand and their classroom practices. Teachers' beliefs about the aims of education, about how learners learn, and about how curriculum should be structured, have the potential to be determining factors in the teachers' understanding and choice of appropriate pedagogical strategies (Waters-

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Adams, 2006). Harwood, Hansen, and Lotter (2006) further argue that while the factors that influence teachers' practices are complex and numerous, teachers' beliefs have been found to colour and influence teachers' teaching practices, how they believe content should be taught, and how they think learners learn.

Teacher beliefs and attitudes often act as filters through which information about learners, learning, and instructional strategies flow, and teacher beliefs and attitudes can act as considerable constraints or support to implementing inquiry-based teaching methodologies (Lotter, Harwood & Bonne, 2007). Teachers' understanding of teaching is enacted in and through the learning activities they give to their learners, and teachers' beliefs and attitudes can lead teachers to redefine, distort and interpret information in different ways (Lotter, Harwood & Bonne, 2007; Glassett & Schrum, 2009).

An understanding of teachers' practical teaching theories and elements that influence the theories are essential if teachers are to value and use reformed teaching strategies, such as inquiry-based teaching and learning in their classrooms (Lotter, Harwood & Bonner, 2007). Therefore the understanding of teachers' belief structures is essential to improving teacher's professional preparations and development (Pajares, 1992).

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1.2 BACKGROUND AND RATIONALE OF THE STUDY

An understanding of teachers' beliefs and attitudes as they relate to their classroom practices, might help in finding ways to overcome barriers associated with using inquiry-based teaching and learning approaches in science classrooms (Saad & BouJaoude, 2012). Teachers' beliefs and views of what constitutes effective teaching and learning influence their choices of instructional strategies, and it is only if teachers have a positive attitude towards inquiry-based teaching and learning that teachers can choose inquiry as opposed to the traditional method of transmitting knowledge (Lotter, Harwood & Bonner, 2007). Glassett and Schrum (2009) argue that teachers' knowledge of inquiry-based teaching and learning strategies, their beliefs and attitudes about inquiry, will shape what they choose to do in their classrooms regarding inquiry. There is a therefore a strong view that teachers' attitudes and beliefs are a strong predictor of their intentions and willingness to implement inquiry-based teaching and learning strategies (Mistades, 2007).

To fully understand classroom practices and develop teacher developmental education programmes that are designed to help prospective and in-service teachers, teacher attitudes and beliefs are important considerations that should not be ignored (Luft & Roehrig, 2007; Mistades, 2007). Teachers' negative attitudes and beliefs about inquiry and their lack of knowledge about inquiry and inquiry skills have been identified as major hurdles for implementing inquiry-based teaching and learning (Saad & BouJaoude, 2012). For teachers to be able to teach through inquiry-based approaches, it is required of them to transform from traditional teaching practices, in which the teacher transmits knowledge to the learner, to constructivist approaches, in which the teachers and learners engage in social and physical experiences to build knowledge (Yerrick, Parke & Nugent, 1977). Therefore, to understand teachers' classroom practices and their inclination towards inquiry-based teaching and learning approaches, it is essential to evaluate the attitudes and beliefs of teachers about inquiry-based teaching and learning.

Studies to investigate the relationship between teachers' beliefs and attitudes about inquiry-based teaching and learning and their classroom practices have been very few and scattered (Saad & BouJaoude, 2012), and most of them have been conducted outside the Republic of South Africa. It is therefore very important within the South African context to assess teachers' science classroom practices and evaluate the incorporation of inquiry-based teaching and learning in their instructional choices, and the extent to which learners are exposed to enquiry learning through science activities.

The South African Physical Sciences CAPS explicitly prescribes scientific inquiry as a strategy to effectively teach and learn Physical Sciences (Department of Basic Education, 2011). Therefore, successful implementation of the Physical Sciences curriculum in South African science classrooms depends largely on teachers adopting and using inquiry-based pedagogical strategies to deliver the curriculum. The evaluation of South African teachers' beliefs and attitudes about inquiry-based teaching, and the relationship between teachers' attitudes and beliefs and their classroom practices, will provide the much-needed answers to questions about the delivery of the Physical Sciences curriculum in science classrooms as envisaged by the curriculum developers.

The study therefore documents teachers' preferences of teaching strategies against their attitudes and beliefs about inquiry-based teaching and learning. The study also presented participating teachers with an opportunity to reflect on their views and perceptions about inquiry-based pedagogical approaches against the prescripts of the South African Physical Sciences curriculum.

1.3 PROBLEM STATEMENT

The role of teachers, especially their choice of strategies that promote and encourage an environment that is conducive for effective teaching and learning, is critical in determining what goes on in the classroom (Anderson, 2002). Effective teaching and learning depends to a large extent to the choices teachers make when planning for the lessons, their decisions during lessons, and the assessment they employ at the end of the lesson (Chan, 2010). Therefore teachers' beliefs, attitudes, and knowledge base play a major role in choices teachers make, and decisions they take on all aspects of their classroom practice, including the decision to use or not to use inquiry-based teaching and learning strategies (Choi & Ramsey, 2009). Renzagilia, Hutchins & Lee (1997) also argue that teachers' beliefs and attitudes are not only reflected in teachers' decisions and actions, but are also evidenced by the important pedagogical decisions they make in their classroom practices.

Chan (2010) argues that inquiry-based teaching and learning entails special pedagogical requirements and challenges for teachers, and teachers' beliefs and attitudes affect their reactions. Therefore, the implementation of an inquiry-based curriculum as envisaged by the South African Physical Sciences CAPS (Department of Basic Education, 2011), depends to a large extent on teachers themselves regarding their beliefs and attitudes, abilities, and interpretations of the curriculum (Pajares, 1992; Chan, 2010). While teachers' beliefs, attitudes, values, theory, and understandings are critical in the process of teachers acquiring an inquiry-based approach to teaching, teachers have been found to base their understanding on classroom practices that work and therefore their understanding takes "the form of practical not theoretical or propositional knowledge" (Anderson, 2002).

In the introduction of the new curriculum in South Africa, teachers were only trained by attending short workshops organised especially during schools holidays and sometimes in the afternoons during working days. These short workshops were aimed

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at exposing the curriculum to the teachers and equipping them with the required skills to be able to deliver the curriculum as envisaged. There is, therefore, a serious need for a study to document the actual teachers' classroom practices in order to gain understanding on the implementation of the newly prescribed curriculum. Among many changes in the new Physical Sciences curriculum, of note is the explicit prescription of scientific inquiry as a preferred teaching strategy in the teaching of Physical Sciences. This explicit prescription of scientific inquiry as a preferred teaching strategy places the South African Physical Sciences curriculum in line with the reform in education internationally. This further compounds the need to assess the attitudes and beliefs of South African teachers to this newly promoted strategy.

1.4 PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of this study was to investigate the beliefs and attitudes about inquiry-based teaching and learning of Grade 10 Physical Sciences teachers in Badplaas and Mashishila educational circuits in the Mpumalanga Province. The aim of the study was to investigate the beliefs and attitudes of Grade 10 Physical Sciences teachers about inquiry-based teaching and learning, in order to explain the relationship between their attitudes and their classroom practices. In order to guide the study and ensure that the aim of the study was realised three research questions and three corresponding objectives were formulated.

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The study was guided by the following research questions:

- What are Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning?
- To what extent is inquiry being implemented in their classrooms?
- What is the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices?

The following objectives are set:

- To use a validated instrument to describe and measure Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning.

- To determine the extent to which inquiry is being implemented in their classrooms.
- To investigate the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices.

1.5 RESEARCH DESIGN

The study was situated in a social constructivist (interpretivist) framework. A sequential explanatory mixed method design was deemed appropriate for this study as Creswell, Plano Clark, Gutmann and Hanson (2003) describe this design as suitable for investigating the perceptions and understandings of a teaching strategy by practising teachers. Quantitative and qualitative data were collected sequentially, and then merged to better understand the teachers' beliefs and attitudes towards inquiry-based teaching and learning within their world of work.

Quantitative data was first collected through a questionnaire, followed by qualitative data, which was collected through the use of selective interviews, classroom observations, and analysis of documents such as worksheets, class work exercises and class tests. It is worth mentioning that the results of this study cannot be generalised with authority because the study only focused on two educational circuits within one district of Mpumalanga. Within the participating schools only teachers teaching Physical Sciences in Grade 10 were invited to participate in the study. Finally, the qualitative data was only collected from three participating teachers through observations and interviews.

1.5.1 Data collection and analysis

Quantitative data was collected using a questionnaire which was distributed to all the Grade 10 Physical Sciences teachers in all the secondary schools (18 secondary schools) within the Badplaas and Mashishila circuits. Eleven teachers from 11 different schools within the two circuits completed the questionnaire. The schools were conveniently sampled because the two educational circuits are close to each other, and the researcher is also a teacher at a secondary school in one of the circuits. The questionnaire which was developed during the European Union-funded project entitled "Promoting Inquiry-based Learning In Mathematics And Science Education" (PRIMAS), was first used as a baseline study in a number of participating European

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countries to investigate the issues of taking up inquiry-based learning (IBL) from the perspective of mathematics and science teachers (PRIMAS, 2011). As a baseline study the questionnaire was aimed at fulfilling two main functions:

- To investigate the current status of IBL in the different teaching cultures and collects information about existing approaches and challenges of implementation in different countries.
- To provide reliable information about the status quo against which ongoing changes can be judged.

The questionnaire provided reliable results about the status and variety of teaching cultures on a large European scale (PRIMAS, 2011). A similar approach is adopted in this study, to use the questionnaire as a baseline study to investigate the beliefs and attitudes about inquiry-based teaching and learning of Grade 10 Physical Sciences teachers in Badplaas and Mashishila educational circuits in the Mpumalanga Province. The questionnaire tested teachers on four constructs: teachers' attitudes about inquiry as a pedagogy, teachers' beliefs and readiness to use inquiry as a pedagogy, teachers' current practices and the extent to which teachers employ inquiry in their teaching practices, and the extent to which teachers engage learners in inquiry-based learning activities (PRIMAS, 2011).

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Teacher's responses to the questionnaire were assessed according to a four-point Likert scale indicating the degree to which participants agreed or disagreed with each given statement. The averages for the scores for each of the constructs were calculated.

From the analysed questionnaire responses, three participants were conveniently sampled for the collection of qualitative data through interviews and lesson observations. Semi-structured interviews were conducted with the three participants individually. All the interviews were audio and video recorded then transcribed, coded and classified to determine patterns regarding the four constructs. Two lesson presentations per participant were observed and video recorded, and lessons artefacts such as worksheets, class work, and class tests were analysed to further gain insight into the extent to which inquiry-based methods were used as a teaching strategy, and the extent to which learners were engaged in inquiry-based learning.

1.5.2 Validity and reliability

Merriam (1998) and Creswell et al. (2003) argue that using a qualitative research design increases the threats to the validity and reliability of the results, while with the quantitative research design trustworthiness and reliability rely mostly on the instrument used to collect data. Trustworthiness of the quantitative data relied on taking time to explain the questionnaire to the participants before they completed it, so that the data supplied could be credible and dependable (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The following was done to check the validity and reliability of the qualitative data (Merriam, 1998; Creswell et al, 2003):

- Triangulation: Multiple and different sources of data, as outlined above, were collected to confirm emerging findings.
- Member checks: The data and tentative interpretations were checked with the participants to confirm whether the participants agreed with the accuracy. The observed lesson presentations and interviews were transcribed and before they were analysed the transcripts were taken to the participants for checking and confirmation or correction of the captured data. Two lessons were observed per participant and a single interview was conducted.
- Peer review: There was ongoing dialogue and critical reflection with other researchers on the research process and tentative interpretations. At all times there was continuous discussion with fellow students conducting almost similar studies. There was also constructive engagement and feedback from the promoter and his assistants.
- Reflexivity: There was ongoing critical self-reflection regarding anything that might bias my interpretation, for example hidden assumptions, own worldview, theoretical orientation, and relationship with the teacher.
- Audits trails: A detailed account of methods, procedures and reasons for decisions is provided in Chapters 3 and 4 of this study.
- Rich description: A detailed description of events will enable readers to contextualise the study and judge the extent to which the findings could apply to their situation is given.

1.6 CONCLUSION

The aim of science education in South African schools and worldwide is to produce scientifically literate learners with well-developed scientific knowledge, and who can think critically based on the nature of science (Panasan & Nuangchalerm, 2010). This is confirmed by the purpose of the South African National Curriculum Statement Grade R-12, which is “to equip learners with knowledge, skills and values necessary for meaningful participation in society as citizens of a free country” (Department of Basic Education, 2011:4).

The definition of Physical Sciences as a subject as stated in Physical Sciences CAPS places knowledge and skills in scientific inquiry at the core of Physical Sciences teaching and learning (Department of Basic Education, 2011). The emphasis on inquiry-based teaching and learning is consistent with the international reforms in education. These international reforms in education emphasise the use of teaching strategies that equip learners with knowledge and skills for the learners to be active participants and contributors in the development of society (Miller, 2007; Department of Basic Education, 2011; Saad & BouJaoude, 2012; Bell, Maeng & Peters, 2013).

It is therefore important that empirical evidence of the beliefs and attitudes of South African teachers towards inquiry-based teaching and learning be documented.

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1.7 OVERVIEW OF CHAPTERS IN THIS STUDY

Chapter 1 provides an overview of the study. The background and rationale of the study is discussed. The problem under discussion, and the purpose and aim of the research are given, as are the objectives and the research questions. The research design, methods of data collection and data analysis are briefly discussed.

Chapter 2 provides a detailed literature review of the theoretical framework as well as the conceptual framework of this study.

Chapter 3 outlines the research methodology and design of the study.

Chapter 4 records the data collected, the analysis of data, and interpretation of the data in the study.

Chapter 5 discusses the findings and trends, and presents limitations and recommendations for further study based on this research.

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CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In this study the literature review consists of a critical analysis of published body of knowledge on inquiry as a reformed teaching strategy, and on teachers' beliefs and attitudes towards inquiry-based teaching and learning (Boote & Beile, 2005). The aim of this literature review is to present results of research conducted on teachers' beliefs and attitudes about the inquiry-based teaching and learning approach, and to relate these results to the ongoing dialogue in the literature (Boote & Beile, 2005). This literature review is also aimed at providing the framework to compare the results of this study with results of other similar studies (Hart, 1998). Key to this literature review will be to find prevailing theories and hypotheses on teachers' attitudes and beliefs about inquiry-based teaching and learning approaches and to find current questions being asked in this topic (Hart, 1998). It is worth mentioning that a large volume of literature exists on worldwide research conducted on inquiry as a reform strategy and teachers' beliefs and attitudes about inquiry-based teaching and learning; however, very few South African based studies on inquiry-based teaching and learning were found, and none on teachers' beliefs and attitudes about inquiry-based teaching and learning.

Education reform processes have presented inquiry as the essence of science education, and inquiry-based teaching and learning is promoted as a central strategy for teaching science (Keys & Bryan, 2001). Inquiry-based teaching and learning is therefore used and considered as characterising good science teaching and learning (Anderson, 2002; Abd-El-Khalick, et al., 2004).

Central to the questions about inquiry are questions about teachers' abilities and readiness to use inquiry, about teachers' willingness to choose and use inquiry as a pedagogical strategy, and about challenges teachers face in the implementation of inquiry in classrooms (Chan, 2010). Teachers and the teachers' education and development are central in the process of educational reform (Anderson, 2002). Teachers' beliefs, attitudes, values and knowledge and how teachers transmit their beliefs, attitudes, values and knowledge in effective practice are therefore very important in the understanding of the role of teachers (Waters-Adams, 2006). The implementation of inquiry-based teaching and learning in science classrooms relies on many factors that are controlled by teachers, mainly teachers' beliefs and teachers' interpretation of the curriculum (Chan, 2010). Therefore the understanding of teachers' beliefs, attitudes and priorities is critical in explaining teachers' classroom experiences (Smolleck & Mongan, 2011). Successful implementation of inquiry-based teaching and learning strategies requires teachers who not only believe that inquiry-based teaching and learning is the best instructional approach to support their learners, but also teachers who are confident in their abilities to teach using inquiry-based approaches (Harwood, Hansen & Lotter, 2006).

2.2 SCIENTIFIC INQUIRY

The most used and widely accepted definition of scientific inquiry is that given by the National Research Council (NRC) (1996, p. 23) in its National Science Education Standards (NSES), which defines scientific inquiry as the "diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work; it also refers to the activities through which learners develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world". Colburn (2000) noted that from this definition scientific inquiry can be placed into two perspectives: inquiry as the description of what scientists do and inquiry as a process involved in the teaching and learning of science.

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Anderson (2007) argued that the goal of science education is the understanding of the work of scientists, the nature of their investigations, and the abilities and understanding required to do this work. Learners should therefore engage in aspects of inquiry as they learn the scientific way of knowing the natural world, and they should also develop the capacity to conduct a complete scientific inquiry (Smolleck, Zembal-Saul & Yoder, 2006). The NSES (NRC, 1996) gives the following as the activities scientists engage in regarding scientific inquiry: making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Scientific inquiry therefore emphasises the essential understandings learners should have about inquiry and the essential abilities necessary for learners to do scientific inquiry (Bell, Maeng & Peters, 2013).

Llewellyn (2005) defines inquiry as both a personal and a professional journey that starts with developing a constructivist-based philosophy and reflecting, both individually and with others, on instructional beliefs and practices. Inquiry is therefore a personal and professional way of seeking information or knowledge through questioning, identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (Florence, 2011). Sikko, Lyngveld, and Pepin (2012) emphasise that inquiry is not to be regarded as a method, nor a procedure or a set of rules, but that it is an attitude towards learning, a willingness to wonder and explore, and collaborate with others in an attempt to find answers when facing new situations and new challenges. Inquiry is therefore a scientific process of exploration by which learners use critical, logical, and creative thinking skills to raise and engage in questions of personal interest (Carin, Bass & Contant, 2005; Llewellyn, 2005; Anderson, 2007; Finn & Finn, 2007).

2.3 INQUIRY-BASED TEACHING AND LEARNING

What learners learn and how they view science is greatly influenced by how they are taught (Sanger, 2007). Inquiry helps learners to construct new knowledge through real-world problem solving based on information gained during experimentation (Panasan & Nuangchalerm, 2010). Learning and therefore knowing becomes an active, adaptive, and evolutionary process through an inquiry-based teaching and learning engagement (Llewellyn, 2005).

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Colburn (2000) defined inquiry-based teaching and learning as a teaching technique in which teachers create situations in which learners are to solve problems, and lessons are designed so that learners make connections to previous knowledge, bring their own questions to learning, investigate to satisfy their own questions and design ways to try out their ideas. Anderson (2002) shows a clear distinction between inquiry teaching and inquiry learning.

2.3.1 Inquiry-based learning

Panasan and Nuangchalerm (2010) defined inquiry-based learning as a practical method for establishing the connections between prior knowledge and scientific descriptions of the natural world. Anderson (2002) defines inquiry learning as an active learning process in which learners are engaged, something that learners do, not something done to them. In an inquiry-based classroom the teacher and the learners are mutually engaged in the process of meaning-making, beginning with authentic questions that grow from their lived experiences in relation to ideas, theories, and information that they encounter and seek to integrate into their continually evolving understanding (Finn & Finn, 2007).

Although there is diversity in the definition of inquiry-based learning, there is commonality of ideas about the core ingredients of an inquiry-based learning (Carin, Bass & Contant, 2005; Llewellyn, 2005; Anderson, 2007; Finn & Finn, 2007; Spronken-Smith & Walker, 2010):

- Learning is stimulated by a scientifically oriented question.
- Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions. Learning is therefore based on the process of constructing knowledge and new understanding.
- Learners formulate explanations from evidence to address scientifically oriented questions. It is therefore an active approach to learning.
- Learners evaluate their experiences in the light of alternative explanations, particularly those reflecting scientific understanding. It is a learner-centred approach to teaching and the teacher’s role is that of a facilitator.
- Learners communicate and justify their proposed explanations. Learning is self-directed with learners taking responsibility for their learning.

These core ingredients of inquiry-based learning emphasise the fact that through inquiry-based learning, learners are actively involved in their learning and learning becomes personal.

Inquiry-based learning therefore has great potential to empower learners with knowledge, skills, and dispositions to become independent thinkers and lifelong learners (Carin, Bass & Contant, 2005; Llewellyn, 2005; Anderson, 2007; Finn & Finn, 2007; Spronken-Smith & Walker, 2010). Inquiry-based learning is characterised mainly by learners’ discourse, cooperative group activities, and teacher scaffolding (Carin, Bass & Contant, 2005). During the discourse learners are encouraged to express their experiences of a natural phenomenon, which gives them an opportunity to compare their experiences with those of other learners within the group, and with the accepted scientific views (Carin, Bass & Contant, 2005). Learners learn to discuss, argue, write about and formally present their ideas, which helps them to focus their attention on what they know, how they know it, and how their knowledge connects to the knowledge of others within the group, to other subjects, and to the world beyond the classroom (Carin, Bass & Contant, 2005). Learning happens mainly when learners reflect on their prior experiences and construct their own mental models, or schemas, as they activate their experiences to develop new conceptual structures (Llewellyn, 2005; Anderson, 2007; Bell, Maeng & Peters, 2013).

2.3.2 Inquiry teaching

Inquiry teaching is a teaching technique which is more learner-centred and less step-by-step teacher-directed learning, and the central strategy is inquiry into authentic questions generated from learners' experiences (Anderson, 2002; Martin-Hansen, 2002). During inquiry-based teaching the teacher's role becomes more of a coach and facilitator, where the teacher helps learners process information, communicates with groups, coaches leaners' actions, facilitates learners' thinking, and models learning by using materials flexibly (Anderson, 2002). The teacher's role is mainly that of scaffolding the learners by supplying enough external support for learners to learn successfully (Carin, Bass & Contant, 2005). While traditional science teaching regards the subject as fixed and static with a set of rules that yield to a correct and single answer when applied, inquiry-oriented science teachers hold a more dynamic view where what is important is learners engagement in activities that provide opportunities for the construction of knowledge of scientific concepts and ideas (Sikko, Lyngved & Pepin, 2012). Instead of bombarding learners with piles of information, the teacher guides and supports the learners towards finding information and making meaning of natural phenomena on their own (Sanger, 2007).

The scaffolding that teachers give through inquiry-based teaching means giving more external support at the start, and gradually removing support until the learners can work and learn on their own (Spronken-Smith & Walker, 2010). As the teacher's support gradually decreases the learner's responsibility and autonomy increases (Anderson, 2002). Inquiry-based teaching continuously challenges learners to acquire new content knowledge above their existing knowledge (Panasan & Nuangchalerm,

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2010). This is consistent with the concept of “zone of proximal development” derived from the work of Lev Vygotsky, which referred to the zone in which learning occurred with the help of a more capable peer (Spronken-Smith & Walker, 2010). Leonard, Barnes-Johnson, Dantley, and Kimber (2011) argue that in the quest to support learners to gradually progress through the levels of inquiry, the teacher should adhere to the following principles: make science accessible; make thinking visible; help learners to learn from each other; and help learners to develop autonomous learning skills. McKimm and Jollie (2007) argue that one of the main tasks of the teacher in an inquiry-based classroom is to establish an appropriate micro-culture within the group, which includes the physical environment, the psychological climate and the interactions between the teacher and the groups and between the individual group members.

Important pedagogical considerations in inquiry-based classroom that define the roles and responsibilities of the teacher include: organising the classroom, crafting and asking questions, using learners’ prior experiences and ideas, holding group discussions, and guiding learners recording (Worth, Duque & Saltiel, 2009). Examples of science teaching models that are consistent with the constructivist learning theory and support inquiry-based instructions are the learning cycle and the 5E model.

The learning cycle consist of three phases which are exploration, during which the teacher provides learners with initial experiences with materials and phenomena that serve as a foundation for introducing science concepts; invention, which is the second phase during which learners are engaged in activities that introduce them to scientific concepts and skills; and finally the discovery phase during which scientific concepts learnt are applied to new situations (Lemmer & du Toit, 2010).

The five phases of the 5E model are: engage, explore, explain, elaborate and evaluate (Bybee, Taylor, Gardner, Van Scotter, Powel, Westbrook & landes, 2006).

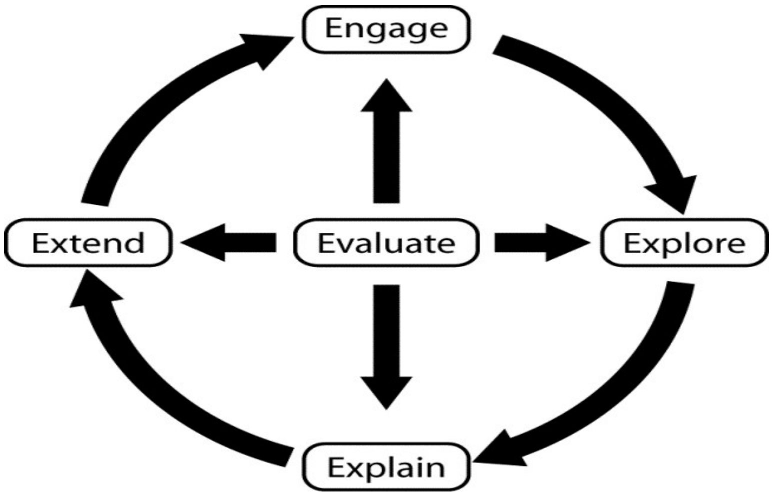

Figure 2.1: The 5E model of inquiry-based teaching and learning (Bybee et al., 2006)

The general goals in each stage in the 5E model include:

Engage

At this stage teachers introduce the topic or concept with an intriguing, fascinating, or challenging question or demonstration to capture learners' interest, curiosity and attention (Bybee, et al., 2006). The teacher engages the learners in the learning task by getting them to mentally focus on the problem, situation or event and making connections to past and future activities (Lemmer & du Toit, 2010). The teacher strategically prompts learners to expose their knowledge related to the topic by engaging them in a discussion.

Explore

During exploration the teacher guides and facilitates the learners in conducting hands-on or problem-solving activities and experiments designed to help explore the topic (Research-Based Curriculum, 2009). The main aim of the exploration phase is to establish experiences that the teacher and the learners can use to formally develop a concept, process or skill (Lemmer & du Toit, 2010). Often learners work in groups and share common experiences.

Explain

During the explanation phase the teacher directs learners' attention to specific aspects of the engagement and exploration phase, guides and supports the learners to explain concepts, processes and skills in a clear, plain and comprehensive way (Bybee, et al., 2006, Lemmer & du Toit, 2010). The teacher then defines relevant vocabulary and helps the learners observe patterns, analyse results, and draw conclusions based on their activities (Bybee, et al., 2006).

Elaborate/Extend

During this phase learners build on the concepts or ideas they have learnt in the previous phases and make connections to other related concepts and new situations (Bybee, et al., 2006). Learners are engaged in further activities that provide further experiences that extend or clarify the concepts, processes or skills already learnt (Lemmer & du Toit, 2010).

Evaluate

Finally the teacher formally or informally evaluates learners' understanding of the concepts learnt (Research-Based Curriculum, 2009). Learners are also given an opportunity to evaluate their own understanding by applying the skills gained (Lemmer & du Toit, 2010)

In all teaching models the transition of learners from one phase to the next phase depends mainly on the support learners get from the teacher, and one key support strategy that is compatible with the constructivist learning principle is questioning (Lemmer & du Toit, 2010). Ramnarain (2011) argues that in an inquiry-based classroom it is essential that teachers ask a "productive" type of question which calls for reflection and analysis, and encourages learners to search for answers and to justify their actions. Teacher questioning plays a pivotal role in guiding learners to obtain a sense of structure and direction of the inquiry, and provides the learners with a bridge towards greater learner autonomy (Lemmer & du Toit, 2010). Teachers can ask four types of questions depending on the type of support needed and the level of inquiry at which the learners operate: these are clarifying, focusing, probing and prompting questions (Lemmer & du Toit, 2010). Teachers ask clarifying questions to help learners to make their thoughts and understanding more explicit, focusing questions are asked to help learners to be more specific instead of being vague or general, probing questions are asked to help learners to explain, justify or expand their original response, and prompting questions are asked to guide learners to a particular direction (Lemmer & du Toit, 2010).

Botha and Seroto (2010) identify eight main characteristics of scaffolding: it provides clear directions; it clarifies the purpose; it keeps learners on task; it offers assessment to clarify expectations; it points learners to worthy sources; it reduces uncertainty, surprise and disappointment; it delivers efficiency; and it creates momentum. Scaffolding should be directed at supporting the group, but mainly individual learners within the group, to progress in completing the inquiry activity at hand but also to progress through the levels of inquiry towards autonomous learners (Botha & Seroto, 2010).

2.4 LEVELS OF INQUIRY-BASED TEACHING AND LEARNING

At the core of inquiry-based teaching and learning, is an inquiry instruction involving active learning that emphasises questioning, data analysis and critical thinking (Florence, 2011). Emphasis is on learners' active participation, being hands on, conducting inquiry into questions formulated based on their life experiences, and seeking answers to make meaning of natural phenomena (Atkin & Black, 2007; Sikko, Lyngveld & Pepin, 2012). The role of teachers and those of the learners varies during inquiry activities depending on the level of development of the learners in conducting an inquiry (Anderson, 2002). A four-level inquiry continuum was identified on the basis of how much information is given to learners and how much guidance and support is provided by the teacher during an inquiry activity (Lemmer & du Toit, 2010; Florence, 2011). Inquiry-based teaching and learning can range from confirmation inquiry, structured inquiry and guided inquiry, to open inquiry.

2.4.1 Confirmation inquiry

Confirmation inquiry is the lowest level of inquiry, and learners confirm a principle through an activity in which the results are known (Florence, 2011). Confirmation inquiry is used to teach and demonstrate an already known concept. The teacher present the learners with the question, the procedure and the data recording sheet (Florence, 2011). Learners follow as in a cookbook in a low level of engagement (Martin-Hansen, 2002). Confirmation inquiry is more teacher centred and learners are reduced to respondents to teacher directed activities (Anderson, 2002; Martin-Hansen, 2002). Confirmation inquiry is best used to teach and acquaint learners with inquiry procedures (Lemmer & du Toit, 2010), to familiarise learners with what a good testable question looks like, how to safely design a procedure to investigate a question, and how to collect and analyse data to form evidence-based conclusion (Panasan & Nuangchalerm, 2010). To engage learners actively in a confirmation inquiry teachers can use techniques such as discrepant events and the Predict-Observe-Explain (POE) method, where in the discrepant events learners are asked to observe and identify unexpected results that are contradictory to their normal experience or expectations, and in the POE method learners are asked to use basic skills of predicting the outcome of the event, observing the results and giving explanation or inference (Lemmer & du Toit, 2010).

2.4.2 Structured inquiry

In structured inquiry, learners investigate the teacher-presented question through a prescribed procedure, but the results are not known to the learners (Lemmer & du Toit, 2010; Florence, 2011). The teacher formulates the question, designs the procedure and determines how the data is to be recorded, and the learners simply follow the given directions as in a cookbook (Martin-Hansen, 2002). Learners are only engaged in the analysis and interpretation of the results; the teacher guides the learners through questions to make the required conclusion (Florence, 2011).

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2.4.3 Guided inquiry

In a guided inquiry, learners investigate the teacher-presented question, but learners design and select procedures and the results are not known to the learners (Lemmer & du Toit, 2010; Florence, 2011). The teacher chooses the question to be investigated and the learners with the help of the teacher design the procedure to be followed in conducting the investigation (Martin-Hansen, 2002). It is during the guided inquiry that the teacher teaches the learners specific skills needed for open inquiry investigations (Martin-Hansen, 2002).

2.4.4 Open inquiry

Open inquiry is the highest level of inquiry and it is fully learner-centred, where learners begin by formulating the questions about a teacher-assigned topic in addition to designing and selecting the procedures (Florence, 2011; Martin-Hansen, 2002). Learners raise questions from their prior experiences relevant to the topic under investigation (Lemmer & du Toit, 2010). The learners resume the role of self-directed learners where they design their own activities, process information, formulate hypothesis, interpret available data, explain their suggested views of a given natural phenomena, and share authority for the answers (Anderson, 2002). Open inquiry mirrors scientists' actual work and requires higher-order thinking skills from the learners (Martin-Hansen, 2002).

The different levels of inquiry are used for different types of lessons and for specific needs in a science classroom (Martin-Hansen, 2002). As the learners progress through the levels of inquiry, teachers give learners more and more autonomy and gradually withdraw their support (Lemmer & du Toit, 2010). Therefore, inquiry-based teaching and learning spans from teacher-centred to more learner-centred classrooms, and these different aspects help teachers to vary the teaching and learning experiences in the science classrooms to better respond to learners' needs (Martin-Hansen, 2002; Panasan & Nuangchalerm, 2010). An inquiry-based science classroom therefore offers both teachers and learners an opportunity to explore science in an exciting and a dynamic way (Colburn, 2000).

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2.5 BENEFITS OF INQUIRY-BASED TEACHING AND LEARNING

One major aspect of scientific inquiry that is central to science instruction is that through inquiry-based teaching and learning learners are actively engaged, which helps the learners to develop scientific habits of mind and to practise important science skills (Carin, Bass & Contant, 2005). Habits of mind are mental habits individuals develop to organise and present their thinking, and they encompass higher-order thinking skills, critical and scientific reasoning skills, problem-solving skills, communication and decision-making skills, and metacognition (Llewellyn, 2005). Engaging in inquiry-based activities improves learners' interpretive skills, scientific writing and reasoning skills, questioning skills, critical thinking skills and deep understanding (Tessier, 2010). Shin & McGee (2002) argue that compared to conventional teaching approaches, inquiry-based approaches significantly improve learners' scientific problem-solving skills and science process skills. These skills collectively lead to a better laboratory experience for learners and improve learners' enthusiasm about science (Tessier, 2010).

Engaging learners in scientific inquiry also leads to achievement gains in science content understanding (Carin, Bass & Contant, 2005). The direct experience with the phenomena being studied that learners will have when engaging in inquiry activities is key to conceptual understanding and helps learners to continuously build their understanding of the world around them (Worth, Duque & Saltiel, 2009). Gibson and Chase (2002) argue that inquiry-based learning is a more effective way for learners to learn science, and learners who learn science using the inquiry approach score higher on science achievement tests. Shin & Mcgee (2002) argue that inquiry-based activities greatly improve learners' cognitive abilities and science achievement. By being actively involved in hands-on activities where the learners describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others, learners actively develop their understanding in science (Ramnarain & Kibirige, 2010). Learners combine process and scientific knowledge as they use scientific reasoning and critical thinking to develop better understanding of the scientific concepts and the nature of science (Llewellyn, 2005; Finn & Finn, 2007). Edelson, Gordin, and Pea (1999) state that inquiry activities contribute to the knowledge acquisition process by providing a meaningful context for learning, and contribute to the development of science content understanding in all of the following ways: inquiry activities can lead learners to confront the boundaries of their knowledge or recognise gaps in that knowledge; the design of inquiry activities places a demand for knowledge on the part of the learner to complete the inquiry successfully; inquiry activities enable learners to uncover new scientific principles and refine their pre-existing knowledge; and inquiry activities give learners the opportunity to apply their scientific understanding, which reinforces their understanding and enriches its connection to other knowledge.

Furthermore, through inquiry-based teaching and learning learners acquire skills necessary to become independent inquirers about the natural world and the dispositions to use the skills, abilities, and attitudes associated with science (Bell, Maeng & Peters, 2013). Learners gain insight into the world of the scientist by engaging in activities that resemble what scientists actually do in their work, which further develops and sharpens the learners' science process skills (Ramnarain, Kibirige, 2010), and learners discover and understand that scientists use many methods to conduct a wide variety of investigations. Scientists rely on technology and mathematics, and scientific explanations must be logically consistent, abide by rules of evidence, be open to questions and modification, and be consistent with current scientific knowledge (Anderson, 2007).

By being actively involved in their learning, learners are motivated to learn science (Ramnarain & Kibirige, 2010), and because inquiry is based on learners' questions emanating from their personal experiences, learners relate the content to their own experiences and therefore develop interest in the science content (McKimm & Jollie, 2007). Inquiry-based teaching and learning helps learners to view science content as real and all around them, and be able to identify the potential for future learning and work (McKimm & Jollie, 2007). This enhances the natural curiosity of learners to understand the natural world (Ramnarain & Kibirige, 2010). Inquiry-based learning leads learners to open their window of opportunities to explore and understand about the natural world themselves (Panasan & Nuangchalerm, 2010). Inquiry-based teaching approaches do not only improve learner achievement in science, but also increase learners' interest and excitement about science (Anderson, 2002; Walker, 2007), improve learners' attitudes towards science (Gibson & Chase, 2002), and improve teachers' confidence in teaching science (Tessier, 2010).

Benefits of inquiry-based science instruction are best summarised by the eight essential elements of inquiry-based science instruction described by Hammerman (2006): inquiry-based instruction develops an understanding of basic concepts; it develops process and thinking skills; it builds understanding of ways that science is linked to technology and society; it builds experience necessary to support and develop or modify interpretations of the world; it enhances reading and writing; it allows for a diversity of strategies for learning; it allows for a variety of ways for learners to show what they do know; and it actively engages learners in a learning cycle.

2.6 BARRIERS IN IMPLEMENTATION OF INQUIRY-BASED TEACHING

Despite the international acceptance of inquiry-based teaching and learning as the best science teaching and learning strategy (Llewellyn, 2005), and the widespread educational reforms to promote the use of inquiry-based approaches (Anderson, 2002), many teachers are still reluctant to adopt this pedagogical approach in their science classrooms (Anderson, 2002; Walker, 2007). Abd-El- Khalick et al. (2004) argue that barriers to the implementation of inquiry in science classrooms range from those localized to those that cut across contexts, from the technical to the political, and from factors associated with science teachers to those related to the culture of school science. Colburn (2000) suggests that problems faced by teachers in the implementation of inquiry-based teaching and learning can be classified into three groups: problems related to the school system; problems related to resources; and problems related to the individual teacher.

Llewellyn (2005) argues that for effective implementation of inquiry-based approaches, teachers must understand precisely what scientific inquiry is; they must have sufficient understanding of the structure of the science content itself; and they must become skilled in inquiry teaching techniques. Therefore the following eight factors have been found to be the main reasons for teachers' reluctance in using inquiry-based teaching and learning in their classrooms.

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2.6.1 Teachers' knowledge and understanding of inquiry-based approaches

Many teachers have been found to be unfamiliar with the concept of constructivism, and therefore have no understanding of inquiry-based teaching and learning (Llewellyn, 2005). Colburn (2000) argues that due to lack of knowledge and understanding teachers are confused about the meaning of inquiry, and some feel it is only appropriate for the high-ability learners. Akerson and Hanuscin (2007) found after a three-year teacher development program that among the reasons teachers give for not implementing inquiry in their classrooms are confusion about the meaning of inquiry, inadequate preparation in inquiry methodology, and viewing inquiry-based instruction as difficult to manage. Without knowledge and understanding of inquiry-based approaches, teachers will never be able to see the benefits and opportunities that come with the inquiry strategy and will continue to teach their learners in exactly the same way they were taught, the traditional way of teaching (Llewellyn, 2005).

Teachers need a solid understanding of inquiry with a teaching framework that builds in accountability for science content learning and ability to use inquiry-based activities to create and manage an engaging, productive science classroom (Carin, Bass & Contant, 2005). Lack of knowledge and the fear of the unknown prevent these teachers from employing the inquiry-based teaching strategy.

2.6.2 Curriculum interpretation

Abd-El-Khalick, Boujaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust and Tuan (2004) in a study conducted involving seven countries, found that the majority of science curricula lacked a coherent and well thought-out framework regarding inquiry, but there were few scattered general ideas about science process skills, experiments, and a universal "Scientific Method". Most of the secondary school science curricula do not present clearly articulated conceptions of scientific inquiry, but present a list of goals for science education that conflates different aspects of inquiry (Abd-El-Khalick et al, 2004). The emphasis on inquiry is not sufficient for fruitful implementation of inquiry approaches to the teaching and learning of science (Abd-El-Khalick et al, 2004).

2.6.3 High-stakes standardised assessment

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Through an inquiry-based approach, assessment becomes flexible and learners are expected to demonstrate their competencies using many different forms of assessment other than the traditional paper and pencil objective type examination (Carin, Bass & Contant, 2005). Inquiry-based approach is therefore in contrast with the high-stakes standardised assessments that are prescribed and compulsory for all learners (Llewellyn, 2005). The need for learners to write the standardised tests at specific times in the curriculum places pressure on teachers, and leads to teachers prioritising factual knowledge that learners can learn through repeated drill and practice, against the implementation of inquiry (Trautmann, MaKinster & Avery, 2004). Teachers employing the inquiry-based approach are faced with the dilemma of finding the balance between providing specific learning opportunities that best respond to learners' prior experiences, and present understanding and reality against preparing learners for the high-stakes standardised examinations (Carin, Bass & Contant, 2005;

Llewellyn, 2005). Teachers mostly choose the traditional content-based method to teach learners and prepare them for the standardised examinations.

2.6.4 Curriculum and standards

Inquiry-based teaching means that standards of achievement and understanding are flexible for differentiated individual instructions (Llewellyn, 2005). Learners make meaning and achieve understanding of given phenomena at their own pace (Bell, Maeng & Peters, 2013). Through an inquiry-based approach teachers and learners can cover fewer topics, but in greater depth, within the allocated time (Llewellyn, 2005). This acts against the prescribed curriculum standards which are set for all learners, and need to be covered within a particular time frame (Llewellyn, 2005; Bell, Maeng & Peters, 2013). This again forces teachers to opt for the traditional method of teaching to cover the expected curriculum standards within the specified timeframe. The state-mandated curriculum requirements and the pressure of the standardised high-stakes testing contributes significantly to teachers opting to employ other strategies rather than inquiry (Binns & Popp, 2013).

2.6.5 Daily schedules and time allocation

Schools also set daily schedules that teachers must cover in their work to be in line with the national set standards, and allocate particular time for all subjects per day which is never enough for an inquiry-based science lesson (Llewellyn, 2005). Binns & Popp (2013) argue that in order for learners to work through ideas and procedures of inquiry-based activities large blocks of time are needed, and the standard 50- to 90-minute classes limit the type of activities that can be completed. Sikko, Lyngved & Pepin (2012), in a survey conducted among Norwegian teachers, concluded that the main hindrance for the uptake of inquiry-based teaching and learning seemed to be time; teachers felt that they did not have sufficient time to prepare inquiry-based lessons, and that there was not enough time in the curriculum to work with the inquiry-based lessons. Implementing inquiry-based lessons requires extra time and energy from the teachers, and this greatly discourages teachers from choosing inquiry-based approaches (Sikko, Lyngved & Pepin, 2012).

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2.6.6 Textbooks

Inquiry-based teaching and learning in line with the constructivist culture, expects that teachers and learners should use a multi-text approach where every textbook is seen as a valuable source (Llewellyn, 2005; Bell, Maeng & Peters, 2013). The use of secondary sources such as books, experts and the internet during learners' exploration is important in inquiry because it complements direct experience (Worth, Duque & Saltiel, 2009). However all schools in South Africa are supplied with only one prescribed textbook per subject and many rural schools do not have functional libraries; therefore the supplied textbook is the only source teachers and learners have, which greatly limits the use of multi-text in many science classrooms (Llewellyn, 2005). Textbooks therefore play an important part in the shaping of lesson content, and textbooks that are not inquiry compliant, and do not include inquiry-based activities, limit the implementation of inquiry-based teaching and learning (Sikko, Lyngved & Pepin, 2012). In science classrooms where learners have no access to multi-text, and the only available textbook is not inquiry compliant, the teacher's role ends up mainly being the source of most of the information and knowledge, and therefore inquiry-based approaches become impossible (Bell, Maeng & Peters, 2013).

2.6.7 Professional development

Abd-El-Khalick et al. (2004) identified the absence of sustained professional development activities that can enable teachers to actualise the advantages of inquiry-based teaching and learning as one of the pitfalls that hamper the implementation of inquiry-based approach. Many teachers feel inadequately prepared for this type of instruction; others have concerns about managing an inquiry-based classroom; some show great allegiance to teaching facts; and others view the purpose of a course as just preparing learners for the next level (Colburn, 2000). Poorly trained teachers are consumed by fears and have low confidence about inquiry, and therefore shy away from an inquiry-based approach (Carin, Bass & Contant, 2005). Because of the fact that inquiry-based activities are unpredictable and the results are not known in advance, teachers are expected to constantly make decisions such as how to initiate inquiry, how to encourage learner discourse, when to shift from small group activities to whole class discussion, when and how to confront misconceptions, when to directly teach needed scientific knowledge, and how best to model scientific skills and

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attitudes. Teachers are then reluctant to feel out of control of what is going on in their classroom (Trautmann, MaKinster & Avery, 2004). Teachers are not confident enough to accept the change in their role from initiator and controller to guide and facilitator; they worry about possibility of discipline problems, excessive preparation requirements, and their lack of knowledge in a particular topic (PRIMAS, 2011).

Teachers are not exposed to professional development programmes which are aimed at addressing teachers' concerns and equipping them with relevant skills to implement inquiry-based teaching and learning (Carin, Bass & Contant, 2005). To cultivate a constructivist culture where inquiry-based teaching and learning is chosen as the main pedagogical strategy, teachers need to develop a new vision about teaching and learning founded on research-based knowledge and then work to change their practices to achieve their new vision (Llewellyn, 2005). Transforming the long-held classroom norms and change past practices requires a support system in the form of professional development programmes sustained over time (Bell, Maeng & Peters, 2013).

2.6.8 Teachers' beliefs and values about inquiry-based approach

Binns and Popp (2013) argue that it is not educational background alone that determines whether a teacher will use inquiry instruction, but teachers' beliefs, values and views of knowledge and how it is acquired or built play a major role. Teachers' beliefs about science, beliefs about the nature of science, beliefs about teaching and learning and beliefs about inquiry-based approaches, form core values that influence teachers' decisions and choices of pedagogical strategies (Sikko, Lyngved & Pepin, 2012). If teachers' core beliefs are in conflict with inquiry practices, they act as a hindrance towards teachers choosing inquiry as a pedagogical strategy (Binns & Popp, 2013).

The implementation of inquiry-based teaching and learning in science classrooms depends to a large extent among other factors on teachers' attitudes and beliefs (PRIMAS, 2011).

Reasons why science teachers may not use inquiry-based teaching and learning are best summarised by Colburn (2000) as confusion about the meaning of inquiry, the belief that inquiry instruction only works well with high-ability learners, teachers feeling inadequately prepared for inquiry-based instruction, inquiry being viewed as difficult to manage, an allegiance to teaching facts, and the purpose of teaching being seen as preparing learners for the next level.

This study is aimed first at documenting and understanding beliefs and attitudes about inquiry-based teaching and learning of South African teachers within the Badplaas and Mashishila circuits. The study will further explore how these beliefs and attitudes influence the teachers' choices of pedagogical strategies, which translate to their classroom practices. Crawford (2007) argues that there are many mediating factors that serve to influence a teacher's ability to play out his or her beliefs in practice. In an attempt to understand teachers' choices of instructional strategies and classroom practices, efforts will be made to identify practical reasons and factors that influence their choices over and above their beliefs and attitudes.

2.7 TEACHERS' ATTITUDES AND BELIEFS

Pajares (1992) argues that there has been difficulty among researchers in defining beliefs and belief systems, and that beliefs have been confused with knowledge. As a result distinguishing knowledge from beliefs continues to be a challenge (Pajares, 1992). Leonard, Barnes-Johnson, Dandle and Kimber (2011) define beliefs as existential presumptions, which are the personal truths everyone holds and are characterised by making judgements and evaluations about phenomena, subject matter, and individuals, this is adopted as the main definition. Beliefs are therefore mental constructions of experience often condensed and integrated into schemata or concepts that are held to be true and guide behaviour (Sigel, 1985). Beliefs can also be explained as dispositions to action and major determinants of behaviour (Brown & Cooney, 1982). Beliefs are therefore an individual's representation of reality that has enough validity, truth or credibility to guide thought and behaviour (Pajares, 1992). There is commonality among researchers that beliefs have unique composition and cognitive affiliation, and they are personal constructions, entities that belong to an individual (Luft & Roehrig, 2007).

Pajares (1992) identified four features characteristic of beliefs which distinguish beliefs from knowledge: existential presumptions, alternativity, affective and evaluative loading, and episodic structure. Existential presumptions refer to the incontrovertible, personal truths everyone holds. Alternativity is a mental state where individuals for

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varying reasons and experiences attempt to create an ideal or alternative situation that may differ from reality. Affective and evaluative loading suggest that beliefs have stronger affective and evaluative components than knowledge and that affect operates independently of the cognition associated with knowledge. Episodic structure refers to the fact that beliefs draw their power from previous episodes or events that create intuitive screens through which new information is filtered.

Pajares (1992) further argues that beliefs offer greater insight into human behaviour than knowledge. Clusters of beliefs around a particular object or situation form attitudes that become action agendas that guide decisions and behaviour (Pajares, 1992). The connections among clusters of beliefs create an individual's values that guide one's life and ultimately determine behaviour (Lumpe, Haney & Czerniak, 2000). Beliefs are also surrounded by an emotional aura that dictates rightness and wrongness, whereas knowledge is emotionally neutral (Pajares, 1992). Beliefs influence what teachers say outside the classroom (Pajares, 1992), and they are more encompassing of the total environment in which the teacher operates (Lumpe, Haney & Czerniak, 2000). Beliefs filtered by experience influence their behaviour in the classroom, while knowledge on the other hand represents efforts to make sense of experience, and knowledge ultimately influences teacher thought and decision making (Pajares, 1992). Beliefs are based on evaluation and judgement and knowledge is based on objective fact (Pajares, 1992).

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All teachers hold beliefs about their work, their learners, their subject matter, and their roles and responsibilities (Pajares, 1992). Clark (1988) defined teachers' beliefs as preconceptions and implicit theories that are drawn from personal experience, beliefs, values, biases, and prejudices. Teachers' orientations to teaching are determined by teachers' beliefs about learners and the learning process, about the role of the schools in society, and about teachers themselves, the curriculum, and pedagogy (Pajares, 1992). Teachers' beliefs and attitudes affect teachers' pedagogical practice and therefore play an important role in the development of learners' attitudes and beliefs towards science (Sikko, Lyngveld & Pepin, 2012). Hativa and Goodyear (2002) argue that there are intriguing parallels between the development of learners' beliefs about learning and the development of teachers' beliefs about teaching.

Teacher's beliefs can provide an understanding of a teacher's practice; they can guide instructional decisions, influence classroom management, and serve as a lens of understanding for classroom events (Luft & Roehrig, 2007). Tiberius (2001) argues that beliefs that teachers hold about the appropriate roles and responsibilities of teachers shape the ways they teach and the ways they think about teaching. Teachers' instructional choices and approaches to teaching and learning are greatly influenced by their beliefs and attitudes (Ortega, Luft & Wong, 2013). Teachers' beliefs about inquiry-based teaching and learning are therefore the strongest predictors of teachers' motivation to choose inquiry- based approaches, and teachers' behaviour in science classrooms (Leonard, Barnes-Johnson, Dantley & Kimber, 2011).

Equally important in teachers' choices of a pedagogical strategy and teachers' behaviour is the teachers' self-efficacy which is a substructure of beliefs and incorporates attitudes and values which are part of a belief network (Leonard, Barnes-Johnson, Dantley & Kimber, 2011). Self-efficacy is a formidable paradigm that operates on motivation, is grounded in social learning theory, and consists of two dimensions: personal self-efficacy which is a judgement of one's ability to organise and execute given types of performances; and outcome expectancy which relates to an individual's judgement of the likely consequences such performances will produce (Smolleck & Mongan, 2011). The two dimensions work together in powerful ways to influence behaviour, and impact the amount of perseverance and effort an individual will undertake when working towards achieving an objective (Saad & BouJaoude, 2012).

Self-efficacy influences the choices individuals make and the courses of action they pursue, and therefore high self-efficacy leads to greater effort, persistence and resilience during challenging events (Pajares, 1992). Strong teachers' beliefs in their ability to implement an inquiry-based teaching and learning strategy can be the determining factor in teachers choosing inquiry as a pedagogical strategy and can influence teachers' chosen roles and responsibilities in science classrooms (Anderson, 2002). Highly efficacious teachers will be intrinsically motivated, set high standards for their learners, take ownership of the learning process, and devote more class time to academic activities (Leonard, Barnes-Johnson, Dantley & Kimber, 2011).

2.8 TEACHERS' ROLES AND RESPONSIBILITIES

Teachers' beliefs about teaching strategy determine the roles teachers will assume during the teaching process and determine the preparations that precede the lesson. Tiberius (2001) identified four roles that teachers can assume based on their beliefs.

2.8.1 The content expert role

The teacher who holds this view sees himself/herself as more of an expert who serves mainly as a source of knowledge. The teacher's main focus is to maintain current knowledge in the subject matter. The teacher mainly organises needed knowledge and other resources, and learning becomes the responsibility of the learners. Learners are given a more autonomous role to direct their learning using the resources and the information presented by the teacher. The teacher, as an expert, presents all the information needed for the learning and learners are just recipients of the prepared information.

The differences in the roles of the teachers and the learners are very clear and distinct. The teachers' beliefs are that learning is only possible if learners are presented with all the relevant and current information. How the learners deal with the load of information given becomes their responsibility and the teacher is not involved.

2.8.2 The performance role

These are teachers who make an effort to make learning happen by transmitting information or shaping learners. These teachers organise and clarify the material to shape the learning of the learners. These teachers assume the role of being agents of learning. Teachers who are performers employ different skills which include telling, explaining, and giving feedback to the learners. These teachers take responsibility for organising the relevant content knowledge but also to ensure that it is presented in such a way that learning does take place.

Teachers who resume the performance role believe that it is the responsibility of the teacher to teach but also to ensure that learning does take place. These teachers will take time to prepare thoroughly by collecting relevant and current information needed, but also by adopting the right and effective teaching strategy. These teachers end up

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doing all and relegate learners to recipients of prepared and polished information. Learners learn by imitating and emulating what teachers do.

2.8.3 The interactive role

Interactive teachers believe that learning can be facilitated by interacting with the learners. Through interacting these teachers try to find out more about their learners so that they can develop teaching interventions to target specific needs. These teachers aim at facilitating the connection between the subject matter and the active learning learner. These teachers subscribe to the constructivist view that learners can construct their learning by being active participants. Through interaction the teachers are encouraging the learners to actively engage with the subject matter to facilitate learning (Glassett & Schrum, 2009).

Teachers who subscribe to the interactive role prepare by collecting all the relevant and current information, but also to find a teaching strategy that will stimulate learners to be active participants during the lesson. These teachers assume the role of facilitators in the learning process. They create a conducive environment for learners to take responsibility for their learning, and provide the needed support during the learning. These teachers subscribe to the belief that learners learn by constructing their own meaning of the real world, and therefore they teach by providing learners with information and support for the learners to construct their own meaning.

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Teachers who believe in the interactive role create a space and atmosphere for inquiry teaching and learning to take place. If the teachers possess the knowledge and skills for inquiry teaching and believe in the interactive approach, it becomes possible for learners to learn through inquiry to an extent.

2.8.4 The relational role

Relational teachers mainly use relationships and personal engagement for the purpose of helping the learners. Teachers assume a relational role when they discover that learners are persons and that the effectiveness of their teaching is dependent on the quality of their relationships with learners. This is the highest level that the teachers come to after years of teaching and after the content has been mastered and the teaching performance improved. The teacher then shifts the focus to building alliances that are authentic and trusting relationships with their learners to enhance the learning of the learners.

The teacher who resumes a relational role is engaging with the learners interactively at an advanced level. The teacher recognises that the learners are capable humans that need to be engaged for effective learning to take place. At this level learners are actively involved in their learning and fully understand their roles. The teacher assumes the role of the trusted facilitator that supports learners through their discoveries and learning. The teacher understands the needs of each learner and the support needed for each learner to learn effectively. The learners are given space and support for them to take full charge of their learning.

2.9 PERSPECTIVE TRANSFORMATION

Changes in belief systems of teachers takes place very slowly and are attached to strong emotions and qualify as perspective transformation (Tiberius, 2001). Belief systems are dynamic and permeable mental structures, susceptible to change in light of experience, and the relationship between beliefs and practice is a dynamic two-way relationship (Glassett & Schrum, 2009). A change in the teacher's belief system will lead to a change in the teacher's roles and responsibilities. Teachers define their roles and responsibilities on the basis of their beliefs (Tiberius, 2001).

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Teachers' beliefs act as filters through which information about learners, learning and instructional strategies flow, and this filtering can lead teachers to redefine, distort, or interpret information in different ways (Lotter, Harwood & Bonner, 2007). Teachers' beliefs have been found to be difficult to change because they are based in part on their practical teaching knowledge that is learnt over many years of classroom experience (Lotter, Harwood & Bonner, 2007). Teachers' classroom experiences include what was learnt from their teachers as learners themselves and knowledge accumulated during their teaching experiences. Entrenched beliefs and attitudes of experienced teachers who have been practising for years are even more difficult to transform.

Teachers' practical knowledge is defined as the integrated set of knowledge, conceptions, beliefs and values which teachers develop in the context of the teaching situation (Lotter, Harwood & Bonner, 2007). Teachers' practical knowledge shapes teachers' beliefs and attitudes and helps them develop theories that drive the decisions they make in their classrooms (Lotter, Harwood & Bonner, 2007). Teachers' beliefs and attitudes are developed and shaped by their experiences in the teaching context, and therefore changing teachers' beliefs and attitudes must happen over a longer period and should form part of teachers professional development programmes.

Teachers' knowledge, conceptions, beliefs, values and teaching theories develop and change through a process of practice-centred inquiry (Lotter, Harwood & Bonner, 2007). The practice-centred inquiry process involves the teacher deciding whether a new teaching idea is valuable and plausible, testing the idea out in the classroom, reflecting on the experience and its result, and if satisfied, incorporating the idea into his/her conception of effective teaching (Lotter, Harwood & Bonner, 2007).

The process of the transformation of the teachers' knowledge, conceptions, beliefs and values and teaching theories is not an easy and straight forward process emanating from the practice-centred inquiry. Four essential elements that influence a teaching theory have been identified as core features that influence whether the teachers will value and use a teaching theory.

2.9.1 Teachers' views of science

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Teachers' epistemological views of science are consistent with their instructional beliefs and practice, and have been shown to influence how science is conducted and portrayed in the teacher's classroom (Lederman, 1992; Lotter, Harwood & Bonner, 2007; Tsai, 2007). Based on their epistemological views of science, researchers have classified teachers into learning and knowledge constructivists and learning and knowledge empiricists (Lotter, Harwood & Bonner, 2007). Learning and knowledge constructivist teachers hold views and beliefs that support reformed teaching processes. Their judgement of the value and effectiveness of any teaching theory will be biased towards conceptual change processes. Teachers who hold the learning and knowledge constructivist view are better poised to embrace the inquiry teaching and learning theory.

Learning and knowledge empiricist teachers hold views and beliefs that teaching and learning takes place when the teacher gathers all the facts and transmits the knowledge in a way that ignores learners' preconceptions. Teachers who hold the learning and knowledge empiricist view will judge any teaching theory on its ability to transmit knowledge to the learners. Teachers who hold this view base their pedagogical decisions on the need to cover the set content in their curriculum and learners learning rather than the nature of science as a discipline (Lotter, Harwood & Bonner, 2007).

2.9.2 Teachers' views of learners' abilities

Teachers' beliefs about their learners' abilities to learn influence their instructional decisions and selections of teaching theories (Lotter, Harwood & Bonner, 2007). The use of inquiry teaching and learning was found to be constrained by teachers' beliefs that their learners were immature or incapable of completing complex laboratory activities without explicit teacher guidance (Lotter, Harwood & Bonner, 2007). Teachers' selection of a teaching strategy will be influenced by their judgement of the effectiveness of the teaching strategy based on their beliefs about the abilities of their learners.

2.9.3 Teachers' views of effective teaching

Teachers' instructional decisions will further be influenced by teachers' views of what constitutes effective teaching and learning (Lotter, Harwood & Bonner, 2007). Teachers' views of science and their beliefs in the abilities of their learners all add up in influencing the teachers' views of effective teaching and learning. Teachers who hold the learning and knowledge constructivist view of science will evaluate a learning experience differently from a teacher who holds the learning and knowledge empiricist view.

Teachers' views of effective teaching can motivate and support teachers in choosing an inquiry-based teaching and learning strategy. Teachers who believe that learners' learning should involve high-level thinking are more likely to choose inquiry as a teaching strategy. Teachers' views of effective teaching can also act as constraints on teachers' instructional choices. If the teachers' views on effective teaching are at odds with inquiry teaching practices, their views will influence their choices of teaching theories against inquiry teaching and learning. However, conflict between teachers' espoused and enacted theories of teaching and learning, where teachers believe that inquiry is effective, but for various reasons do not enact that belief, have been identified in many studies (Moseley & Ramsey, 2008).

2.9.4 Teachers' orientations towards teaching science

Teachers' orientations towards teaching science are defined as teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular grade (Lotter, Harwood & Bonner, 2007). Teachers' beliefs about the subject matter and the conceptual understanding of the concepts, their beliefs about the affective goals in doing the subject, the means and resources in the teaching and learning of the subject, can constrain or support the use of inquiry-based teaching and learning strategy (Moseley & Ramsey, 2008).

2.10 CONCLUSION

Current reforms in science education emphasise teaching science for all, with the ultimate goal of developing scientific literacy through inquiry-based teaching and learning (Bell, 2009). Mistades (2007) argues that salient to teachers initiating inquiry are four beliefs: inquiry increases learner enjoyment and interest in science, fosters positive scientific attitudes and habits of mind, helps learners learn to think independently, and makes science relevant to the learners' everyday lives. While most educational documents such as educational policy documents, support and require the introduction of inquiry-based teaching and learning, the implementation of inquiry in science classrooms remains a challenge for many teachers (PRIMAS, 2011). Teachers' attitudes and beliefs have been singled out as the major barrieres to teachers choosing and implementing inquiry in their science classrooms (Luft & Roehrig, 2007).

Teachers' attitudes, beliefs and knowledge have been recognised as integral elements of what they do in their classrooms (Waters-Adams, 2006). The relationship between teachers' attitudes, beliefs and knowledge, and their classroom practice on the other hand, plays a major role in influencing teachers' choices of pedagogical strategies (Pajares, 1992).

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CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the research design and methods that were used to investigate Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning and their influence on teaching practice. The following main questions were addressed to reveal teachers' beliefs and attitudes about inquiry-based teaching and learning.

1. What are Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning?
2. To what extent is inquiry being implemented in their classrooms?
3. What is the relationship between these teachers' beliefs and attitudes about enquiry and their classroom practices?

The research design for this study was modelled around a study conducted by the Promoting Inquiry-based learning in Mathematics and Science Education Project (PRIMAS, 2011) involving a number of European countries funded by the European Union, which was aimed at measuring teachers' beliefs and attitudes about inquiry-based teaching and learning and their influence on practice. The research design involved a teachers' questionnaire, individual interviews with identified teachers, classroom observations, and a review of classroom artefacts.

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Based on the research questions posed above, the following objectives were determined for this study:

1. To use a validated instrument to describe and measure Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning.
2. To determine the extent to which inquiry is being implemented in their classrooms.
3. To investigate the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices.

3.2 RESEARCH DESIGN

A sequential explanatory mixed method research design was chosen for this study (Creswell, 2009). Research designs are procedures for collecting, analysing, interpreting and reporting data in research studies; it is the way in which the research is conceived and executed, and how findings are eventually put together (Henning, van Rensburg & Smit, 2004). Creswell (2009) defines research design as plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis. A research design should be tailored to address the research questions (Henning, van Rensburg & Smit, 2004). This study utilises a sequential explanatory mixed methods design (Creswell, 2009, p. 211) to collect quantitative data as the core of the study, followed by the collection of qualitative data.

Mixed methods design may be fixed and/or emergent. Fixed mixed methods design are mixed methods studies where the use of quantitative and qualitative methods is predetermined and planned at the start of the research process, and the procedure is implemented as planned, while emergent mixed methods designs are found in mixed methods studies where the use of mixed methods arises due to issues that develop during the process of conducting the research (Creswell, Plano Clark, Gutmann & Hanson, 2003). This study utilises a fixed sequential explanatory mixed method where both the quantitative and the qualitative data collection methods are preplanned (Creswell, Plano Clark, Gutmann & Hanson, 2003).

Mixed methods designs can also be concurrent, sequential, or a multiphase combination: concurrent timing occurs when the researcher implements both the quantitative and qualitative methods during a single phase of the research study; sequential timing occurs when the researcher implements the strands in two distinct phases, with the collection and analysis of one type of data occurring after the collection and analysis of the other type; and the multiphase combination timing occurs when the researcher implements multiple phases that include sequential and/or concurrent timing over a programme of study (Creswell, Plano Clark, Gutmann & Hanson, 2003).

Sequential explanatory mixed method is used mainly to explain and interpret quantitative results by collecting and analysing follow-up qualitative data (Creswell, 2009, p. 211). The quantitative data was the priority for addressing this study, and the qualitative data was used to explain the initial results from the quantitative data (Creswell, Plano Clark, Gutmann & Hanson, 2003). Quantitative data was collected first by means of the questionnaire that was delivered to all the 18 schools offering Grade 10 Physical Sciences within the Badplaas and the Mashishila education circuits. Completed questionnaires were personally collected by the researcher from the participating school and teachers. Qualitative data was then collected using semi-structured interviews, observation of classroom practices, and the analysis of classroom artefacts like learners' classwork exrcises books, worksheets, and class tests. The mixing of the two methods was done during data collection, because data collected quantitatively was used to formulate interview questions and to select participants for the collection of the qualitative data (Creswell, Plano Clark, Gutmann & Hanson, 2003).

3.3 RESEARCH METHODS

Research methods involve the form of data collection, analysis, and interpretation that researchers propose for their studies (Creswell, 2009). Data collection in this study included the following stages as suggested by Creswell (2009): site selection, gaining access and obtaining permission, building rapport, generating and recording data, and analysing data.

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3.3.1 Site selection

The study focused on all the schools within the Badplaas and Mashishila circuit that offered Physical Sciences in Grade 10. The questionnaire was delivered by the researcher to all the 18 schools and all the schools had only one Physical Sciences teacher in Grade 10, and therefore 18 questionnaires were distributed. All the schools are rural schools and classified as quintile 1 (no fee schools) where the parents do not pay any school fees for their children to attend the schools.

Because the researcher is also a Physical Sciences teacher in Mashishila circuit, the researcher was known to most of the teachers and this made the distribution of the questionnaire easy.

3.3.2 Gaining access and obtaining permission

Before visiting the schools and distributing the questionnaire, permission to conduct the study was requested from the Mpumalanga Department of Education in Nelspruit. A formal letter explaining the purpose of the study was written to this effect and submitted via the District office. A letter of request was also written to the principals of all the schools with Grade 10 in the Badplaas and Mashishila circuit as well as the Grade 10 Physical Sciences teachers in those schools. The letter of request explained the purpose of the study to the principals and the teachers, and also explained in detail what was expected of the teachers as well as their rights if they decided to be part of the study. Among other things the letter explained that participation in the study was voluntary, and that participants may withdraw from the study at any stage without giving reasons. The letter further assured participants that the information collected during the study will not be used for any other purpose except the study.

3.3.3 Building rapport

When delivering the questionnaire the researcher had personal discussions with the teachers, and given the fact that the researcher was known to the participants prior to the study, it made it easy to build good relationship with most of the participants. Discussions with the principals also allayed the concerns that the study would disrupt the normal functioning of the school, and this assisted in gaining support from the school authorities.

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3.3.4 Generating and recording data

A variety of methods were used to generate the data, with the view of gaining a better and a deeper understanding of teachers' beliefs and attitudes about inquiry-based teaching and learning (Creswell, 2009). The data generating methods in this study were:

3.3.4.1 Questionnaires

A questionnaire was used in this study to provide quantitative data which made it possible to get numeric description of teachers' beliefs and attitudes about inquiry-based teaching and learning (Creswell, 2009). The data collected was analysed statistically to give meaning to the participants' beliefs and attitudes (Henning, van Rensburg & Smit, 2004).

This method of data collection was ideal for the first part of the study to collect quantitative data. The questionnaire used consisted of 58 closed questions testing teachers beliefs and attitudes about inquiry-based teaching and learning (PRIMAS, 2011).

3.3.4.2 ***Semi-structured interviews***

Henning, van Rensburg and Smit (2004) present two main trends of interviews: the standardised conventional interview, and the discursive, constructionist interview. The standardised interview is used to yield more or less accurate information through the responses of an interviewee, and should be used objectively and neutrally (Henning, van Rensburg & Smit, 2004). The standardised interview is mainly conducted with minimal interference or conversation from the interviewer; the interviewee is believed to give a true or real subjective version of facts, opinion and feelings as expreienced (Henning, van Rensburg & Smit, 2004). Discursive oriented interviews are characterised by talk as social action between the interviewer and the interviewee (Henning, van Rensburg & Smit, 2004).

In this study the discursive oriented interview was employed where there was an engagement between the interviewer and the interviewee to make meaning of the phenomena under discussion.

3.3.4.3 ***Classroom observations***

Classroom observations of lesson presentations were observed to further determine the use of inquiry-based approaches during the physical sciences lesson. Observations were conducted with minimal interference, and teachers were encouraged to conduct as normal a lesson as possible. There was no disruption or intervention from the researcher before and after the observed lessons. The RTOP was used to analyse the lessons.

RTOP is an observational instrument designed to measure reformed teaching (Piburn & Sawada, 2000). RTOP was designed to define and allow the assessment of learner-centred teaching and is aligned with the theoretical underpinnings of inquiry-based teaching (Ebert-May, Derting, Hodder, Momsen, Long & Jardeleza, 2011). With the promotion of reformed teaching emphasising the use of teaching strategies that places the nature of scientific inquiry at the centre, there was therefore a need for an instrument to measure the implementation of the reformed teaching strategies in science classrooms (Piburn & Sawada, 2000). RTOP was designed based on reform science education recommendations for science teaching (Piburn & Sawada, 2000). Therefore, consistent with the recommendations of reform science education, RTOP identified the following activities and skills that a teacher should display during a lesson (Piburn & Sawada, 2000):

- Focus on and support inquiries while interacting with learners.
- Orchestrate discourse among learners about scientific ideas.
- Challenge learners to accept and share responsibility for their own learning.
- Recognise and respond to learner diversity and encourage all learners to participate fully in science learning.
- Encourage and model the skills of scientific inquiry as well as the curiosity, openness to new ideas and data, and scepticism that characterise science.

RTOP is a lesson observation and evaluation tool with 25 descriptive statements that are subdivided into five categories, each category consisting of five statements (Rushton, Lotter & Singer, 2011). The five RTOP categories are: Lesson Design and Implementation, Content Propositional Pedagogic Knowledge, Content Procedural Pedagogic Knowledge, Classroom Culture Communicative Interactions, and Classroom Culture Learner/teacher Relationships (Piburn & Sawada, 2000). Each statement is assessed on a 5 point Likert scale ranging from 0 (never occurred) to 4 (very descriptive) (Piburn & Sawada, 2000; Rushton, Lotter & Singer, 2011). In assessing and evaluating lessons focus is on the five categories and how well the lesson activities can fit the descriptions of each of the categories (Ebert-May, Derting, Hodder, Momsen, Long & Jardeleza, 2011):

(1) Lesson design and implementation: how well the instructor elicits learners' prior knowledge, to what extent the teacher engages learners and allows them to influence the focus and direction of the lesson;
(2) Propositional knowledge: how a teacher implements discipline-specific content;

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(3) Procedural knowledge: the inquiry process learners use in the lesson;
(4) Communicative interactions: the proportion and variety of discussion that occurs among learners and between the teacher and learners; and
(5) Learner-teacher relationship: attitudes of the teacher and learners towards each other and the quality of their interactions.

The instrument totals 100 points, and observed lessons are given a summative score where a score above 50 is considered to be indicative of a reformed-based lesson (Piburn & Sawada, 2000; Rushton, Lotter & Singer, 2011). Higher scores represent more learner-centred classrooms where learners actively participate, take primary responsibility for their own learning, interact with each other, and shape the direction of the discussion; whereas lower scores indicate teacher-centred classrooms where a lecture is the primary mode of communication, with minimal roles for learners beyond note taking or the use of personal response systems (Ebert-May, Derting, Hodder, Momsen, Long & Jardeleza, 2011). Personal Response System is a form of technology used by teachers in large classes to ask multiple-choice questions to which the learners reply individually by selecting the answer on a hand-held wireless transmitter (Elliott, 2003). The Personal Response System allows the teacher to engage with the learners without one or few dominant learners taking advantage by answering all the questions asked by the teacher. However the interaction between the teacher and the learner is distant. The learners' responses are picked by a computer connected to the receiver and the computer adds the learner's responses which can be displayed on the screen and the learners can see their performances immediately or they can view them later. (Elliott, 2003).

3.3.4.4 ***Documents and artefacts***

Documents and artefacts can be analysed for their historical value, and therefore they are a valuable source of information (Henning, van Rensburg & Smit, 2004). Learners' classroom exercise books, work sheets, and class tests documenting the daily activities that the teacher gives to their learners were analysed to ascertain whether learners are engaged in inquiry-based activities.

3.3.5 Analysing data

Quantitative data was collected using a questionnaire which was distributed to all the Grade 10 Physical Sciences teachers in all the secondary schools (18 secondary schools) within the Badplaas and Mashishila circuits. The questionnaire which was developed during the European Union funded project entitled "Promoting Inquiry-based learning in Mathematics and Science Education" (PRIMAS), tested teachers on four constructs: teachers' attitudes about inquiry as a pedagogy, teachers' beliefs and readiness to use inquiry as a pedagogy, teachers' current practices and the extent to which teachers employ inquiry in their teaching practices, and the extent to which teachers engage learners in inquiry-based learning activities (PRIMAS, 2011).

Teachers' responses to the questionnaire were assessed using a four-point Likert scale indicating the degree to which participants agree or disagree with each given statement. Thereafter the scores for each of the constructs were calculated.

From the analysed questionnaire responses, three participants were conveniently sampled for the collection of qualitative data through interviews and lesson observations. Semi-structured interviews were conducted with the three participants individually. All the interviews were audio and video recorded, and then transcribed, coded and classified to determine patterns regarding the four constructs. From the coded responses common themes were formulated. Two lesson presentations per participant were observed and video recorded. The observed lessons were analysed using the RTOP. Lessons artefacts such as worksheets, class work, and class tests were analysed to further gain insight into the extent to which inquiry-based is used as a teaching strategy and the extent to which learners are engaged in inquiry-based learning.

3.3.6 Triangulation

Triangulation refers to the use of a variety of data collection methods and sources to the investigation of the research questions in order to enhance confidence in the ensuing findings (Henning, van Rensburg & Smit, 2004). Triangulation indicates that by coming from various points or angles towards a measured position a true position is found (Henning, van Rensburg & Smit, 2004). Triangulation also refers to the use of different approaches to working the data or building the interpretive text (Jick, 1979).

In this study two forms of triangulations are employed to investigate the research questions (Jick, 1979):

3.3.6.1. *Between-method triangulation*

Between-method triangulation is the use of two or more research methods. In this study both the quantitative and qualitative research methods are used. Data collected using the qualitative method are used to confirm or reject the data collected using the quantitative method. Themes are created where there is a commonality between the data collected using the two methods.

3.3.6.2. *Within-method triangulation*

Within-method triangulation uses multiple techniques within a given method to collect and interpret data. In this study lesson observations, interviews and document analysis was used to collect and interpret qualitative data. Data from the different data sources was compared in a converging manner to create themes, which were used to answer the research questions.

3.4 TRUSTWORTHINESS, VALIDITY AND RELIABILITY

With the quantitative research design trustworthiness and reliability depend mostly on the instrument used to collect data. Efforts were made to explain fully the questionnaire and all that was expected from the participants. This was done to improve the reliability of the data collected because participants completed the questionnaire on their own with no influence from the researcher. For the qualitative data trustworthiness was monitored by checking the credibility, transferability, dependability and confirmability of the results.

A credibility check was done to ensure that the data collected were an authentic representation of the experiences and practices of the teachers (Baxter & Eyles, 1997). Credibility checks were done to ensure that the study measures what it actually intended to measure. (Shenton, 2004). To ensure credibility in this study purposeful sampling, disciplined subjectivity by the researcher, persistent observation, peer debriefing, and member checking was used (Baxter & Eyles, 1997).

A transferability check was done to ensure that the data collected fitted within the contexts outside the study situation, and this was done by giving thick descriptions of events and observations (Baxter & Eyles, 1997). It is always of concern to demonstrate that results of a specific study apply to a wider population especially if a small sample is used; however the prospects of transferability should not be immediately rejected (Shenton, 2004).

A dependability check was done to ensure that there is consistency in the interpretation of data, and that variability can be tracked to identifiable sources (Baxter & Eyles, 1997). All processes within the study were reported in detail to enable future researchers to repeat the work and possible gain the same results (Shenton, 2004). Dependability was achieved through the use of low-inference descriptors, the mechanically recorded data for better analysis, and by triangulation (Baxter & Eyles, 1997).

A confirmability check was done to assess the extent to which biases, motivations, interests or perspectives of the researcher influenced the interpretations (Baxter & Eyles, 1997). Confirmability ensures that the findings of the study are the results of the experiences and ideas of the participants (Shenton, 2004). Confirmability was done by triangulation and by giving thick descriptions of the audit process (Baxter & Eyles, 1997).

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In summary the following was done in this study to check the validity and reliability of the qualitative data (Merriam, 1998; Creswell, Plano Clark, Gutmann & Hanson, 2003):

- Triangulation: Multiple and different sources of data, as outlined above, were collected to confirm emerging findings.
- Member checks: The data and tentative interpretations were checked with the participants to check if the participants agreed with the accuracy.
- Peer review: There was ongoing dialogue and critical reflection with other researchers on the research process and tentative interpretations.
- Reflexivity: There was ongoing critical self-reflection regarding anything that may bias my interpretation, e.g. hidden assumptions, own worldview, theoretical orientation, and interrelationships with teacher.

- Audit trails: A detailed account of methods, procedures and reasons for decisions is provided.
- Rich description: A detailed description of events to enable readers to contextualise the study and judge the extent to which the findings could apply to their situation is given.

3.5 ETHICAL CONCERNS

Efforts were made to ensure that the study addressed ethical concerns and this included asking and getting ethical clearance from the Ethics Committee of the Faculty of Education, University of Johannesburg. Permission to conduct the study in Mpumalanga Province was also requested and granted. Permission was also asked from the circuit managers of the two circuits in which the study was conducted. Approval was further given by every principal of all the schools which were part of the study. The following principles to ensure ethical conduct were applied to this study.

3.5.1 Informed consent

Consent to participate in the study was requested from every participant, and the purpose of the study was explained to all participants. Participants were informed of the procedure, benefits of the study and the risks involved. All participants were asked to give written consent.

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3.5.2 Voluntary participation

It was explained to participants that participation is voluntary and that participants could withdraw at any stage of the study without giving reasons.

3.5.3 Confidentiality, anonymity and privacy

Participants were informed of all the measures taken to ensure their confidentiality, anonymity and privacy. Participants were not required to supply their names in the questionnaire; no names or schools are used in the analysis of the data; participants were assured that member checks will be conducted of all the information they supplied to ensure that it was correctly captured; and the information collected during the study would be used for the purpose of the study only.

3.6 LIMITATIONS OF THIS STUDY

This study focused on a very small section of the Physical Sciences teacher population within Mpumalanga Province. The study focused on Grade 10 Physical Sciences teachers within two circuits of a District. The success of the study depended mainly on the participants to complete the questionnaire, because the questionnaire was delivered to all participants but participants had to complete the questionnaire during their own time. The researcher was therefore not in control of the completion schedule of the study. The study was also conducted within rural schools where teachers were taking part in a study of this nature for the first time. Teachers showed doubts and were sceptical of becoming part of the study, and this was evident from the number of teachers who completed and returned the questionnaire and the teachers who were willing to be observed in their classrooms. In all the schools that were part of the study, there was only one teacher teaching Physical Sciences in Grade 10. The questionnaire was handed out to all the 18 Grade 10 Physical Sciences teachers in the 18 secondary schools within the two circuits. Only 11 teachers out of a total of 18 completed the questionnaire. Out of the 11 teachers who completed the questionnaire, it became very difficult to get three teachers to agree to be observed in their classrooms and be interviewed. Teachers would agree initially only to withdraw at a later stage and this resulted in a situation where the study could not be completed within the scheduled time. The results of this study could not therefore be generalised with authority because of the small sample used.

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3.7 CONCLUSION

To fully answer the research question a sequential explanatory mixed method approach was chosen (Creswell, 2009). Even though the mixed method is difficult to conduct and manage it is the best design to gives a better picture and better answers to the research questions of this study (Creswell, Plano Clark, Gutmann & Hanson, 2003). This was made possible by first collecting and analysing quantitative data, which was collected using a standardised questionnaire. Quantitative data was analysed statistically to gain numeric descriptions of the Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning. This was followed by the collection of qualitative data using multiple data-collection methods, which included lessons observations, interviews and analysis of documents and artefacts. Classroom observations were analysed using RTOP, and interviews were recorded and transcribed to generate themes. Both the within method and between methods were used for triangulation. Many forms of data collection were employed to ensure triangulation of the data collected. Steps were taken to adhere to the ethical guidelines. During the study efforts were made to ensure the trustworthiness, validity and reliability of the results.

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CHAPTER 4: DATA ANALYSIS AND FINDINGS

4.1 INTRODUCTION

In this chapter the analysis of the data collected in this study is presented in an attempt to address the research questions which were as follows:

- What are Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning?
- To what extent is inquiry being implemented in their classrooms?
- What is the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices?

Firstly, the contextual setting and progress of this research was discussed. Quantitative data generated from questionnaires completed by Grade 10 Physical Sciences teachers were analysed to determine teachers' beliefs and attitudes about inquiry-based teaching and learning. Appropriate tables were used in the analysis of the questionnaire.

Thereafter, data generated from the observation of Physical Sciences Grade 10 lessons presented by three of the identified teachers were analysed. Classroom artefacts including learners' class work books, worksheets, class tests and the teachers' lesson plans were analysed. The data were analysed to determine the relationship between the teachers' beliefs and attitudes and their classroom practices.

Finally, transcripts of interviews conducted individually with the three observed teachers were analysed for further confirmation of teachers' beliefs and attitudes about inquiry-based teaching and learning, and to establish how their beliefs and attitudes influence their choices of pedagogical strategies.

4.2 CONTEXTUAL INFORMATION

The questionnaires were distributed to 18 secondary schools offering Physical Sciences in Grade 10 within the Badplaas and Mashishila circuits of Mpumalanga province. Sixteen of these schools are rural quintile 1 public secondary schools servicing rural and poor communities. As quintile 1 they are no-fee schools where none the learners attending these schools are required to pay any school fees. These schools depend fully on the government grant for all their operations. The two other schools are private schools, but also draw learners from the same rural communities.

Six of the secondary schools, three in each circuit, have been declared Mathematics Science and Technology (MST) schools by the Mpumalanga Department of Education. These schools have received supplies of science equipment as they are expected to focus on mathematics, sciences and technology education. These MST schools have fully equipped and functioning science laboratories. All the other 12 schools do not have fully functioning science laboratories; in some of the schools a building designated as a laboratory does exist, but lacks the resources to make it a laboratory. Only six of the schools had some scientific apparatus and chemicals and teachers and learners were able to conduct some practical investigations.

4.3 PRIMAS QUESTIONNAIRE COMPLETED BY TEACHERS

A teachers' questionnaire which was developed for the European PRIMAS project was distributed to all the 18 Grade 10 Physical Sciences teachers within the Badplaas and Mashishila circuits. The questionnaire was such that it is as brief as possible so that it would not deter teachers from taking part in the study, and at the same time long enough to gather rich data (PRIMAS, 2011). The questionnaire was composed of four sections:

- Personal data
- Professional development
- Inquiry-based learning
- Current practice at classroom level.

Eleven of the 18 teachers completed and returned the questionnaire. It is recognised that the percentage of the teachers who responded is low, but this is consistent with the responses of participants in many other similar researches conducted (Campbell, Abd-Hamid & Chapman, 2009). There are always difficulties in collecting data from large numbers of science teachers (Campbell, Abd-Hamid & Chapman, 2009).

4.3.1 Personal data

The average age of the teachers who completed the questionnaire was 39 years, with the youngest being 25 years and the oldest being 49 years. Ten were males and one was a female. The teachers have been in the teaching profession for between a few months to more than 20 years. Four teachers, the largest group, have been in the teaching profession for between 11 and 15 years.

There was therefore a fair representation of participants from newly appointed teachers fresh from tertiary education through to experienced teachers. There were teachers who were in their first year of teaching Physical Sciences in Grade 10 and teachers who have been teaching for more than 20 years. There were therefore teachers with fewer years of teaching who have only worked as teachers with the current curriculum, and the only encounter they might have had with the older curriculum was when they were learners. There were also those teachers with more years of teaching who have worked with both the old and the new curriculum. These teachers with more teaching years have experienced the transition of the curriculum from the old curriculum to the current curriculum. For the teachers with more teaching years the new curriculum requires them to change from the traditional teacher-centred teaching approaches to the learner-centred inquiry-based approaches.

Apart from Grade 10 Physical Sciences that all the respondents were teaching, seven teachers were also teaching Mathematics, two were also teaching Biology (Life Sciences), and five were also teaching Natural Sciences. The teachers' experiences in the teaching of other subjects placed teachers in a better position to be able to compare and integrate the teaching strategies and the content knowledge of Physical Sciences with teaching strategies and content knowledge of other subjects.

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4.3.2 Professional development

Ten respondents of the 11 responded to this section; one respondent did not complete this section. None of the respondents indicated the number of days they participated in professional developments events over the past years. Five respondents did take part in professional developments events in the past two years, one in the past three to four years, two in the past five to six years, and one in the past seven to eight years.

All the respondents indicated that they have participated in some form of professional development events. The extent of their participation in professional development was relative to their years of teaching. Five of the teachers have attended a professional development event within the past two years. This was expected in view of the efforts by the Department of Basic Education to develop teachers' understanding of the new curriculum. The Department of Basic Education has been conducting workshops for teachers as part of the programme to introduce and implement the new South African curriculum in the form of CAPS. Attendance at these workshops by all serving teachers has been compulsory.

Despite the fact that attending Continuing Professional Development (CPD) was compulsory, four respondents indicated that they attended willingly. An equal number participated in CPD because it was compulsory, and two respondents were not sure whether they attended willingly or because it was compulsory.

Teachers were then asked to express their views on CPD by responding to 12 statements concerning CPD. Teachers were to respond by indicating the extent to which they agree with the statements on a four-point Likert scale ranging from strongly disagree to strongly agree. Table 4.1 below shows the 12 statements about CPD and the teachers' responses.

Table 4.1: Teachers' views on CPD.

	Strongly disagree	Disagree	Agree	Strongly agree
a. Engaging in CPD can help me to become a better teacher.	0	0	6	4
b. Through CPD I can attain greater professional satisfaction.	0	0	5	5
c. I would like more opportunities to undertake CPD.	0	0	6	4
d. CPD is only necessary for those new to the profession.	5	3	1	1
e. CPD is only important for those seeking greater responsibility.	2	4	2	2

f. It is difficult for me to see the value of CPD.	5	3	1	1
g. CPD is necessary to update my repertoire of teaching methods.	0	0	5	5
h. The provision of CPD opportunities can increase staff morale.	0	2	3	5
i. CPD is necessary in order to update subject knowledge.	0	0	4	6
j. Engaging in CPD can make me more confident in performing my role.	0	0	4	6
k. CPD is necessary to update pedagogical skills.	0	0	4	5
l. Teachers with a great deal of professional experience don't need CPD.	5	4	1	0

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(a) With six respondents agreeing and four strongly agreeing, all ten respondents agree with the statement that engaging in CPD can help them become better teachers.

(b) All ten respondents agree with the statement that through CPD they can attain greater professional satisfaction, with five of the respondents agreeing and five strongly agreeing with the statement.

(c) All ten respondents indicated that they would like more opportunities to undertake CPD, with six of the respondents agreeing and four strongly agreeing with the statement.

(d) Eight of the respondents disagree with the statement that CPD is only necessary for those new to the profession, with five of the participants strongly disagreeing and three disagreeing with the statement. However, one respondent agrees and one strongly agrees that CPD is only necessary for those new to the profession.

(e) Six disagree with the statement that CPD is only important for those seeking greater responsibilities, with two strongly disagreeing and four disagreeing with the statement. Four respondents agree with the statement, with two agreeing and two strongly agreeing with the statement.

(f) Eight respondents disagree with the statement that it is difficult for them to see the value of CPD, with five strongly disagreeing and three disagreeing with the statement. Two respondents agree with the statement with one agreeing and one strongly agreeing.

(g) All 10 agree with the statement that CPD is necessary to update their repertoire of teaching methods, with five strongly agreeing and five agreeing.

(h) Eight respondents agree with the statement that the provision of CPD opportunities can increase staff morale, five strongly agreeing and three agreeing. However two respondents disagree with the statement.

(i) All 10 respondents agree with the statement that CPD is necessary in order to update subject knowledge, with six strongly agreeing and four agreeing.

(j) All 10 of the respondents agree with the statement that engaging in CPD can make them more confident in performing their roles, with six strongly agreeing and four agreeing.

(k) Nine respondents agree with the statement that CPD is necessary to update pedagogical skills, with four agreeing and five strongly agreeing. One respondent did not respond to this statement.

(l) Nine of the respondents disagree with the statement that teachers with a great deal of professional experience don't need CPD, with five strongly disagreeing and four disagreeing. One respondent agrees with this statement.

Statements a, b, c, g, h, i, j and k are positive statements about CPD. On a 4-point scale where strongly disagree is assigned 1 and strongly agree assigned 4, the average for the entire positive the average score for the positive statements is 3.44. On average the respondents agree with the positive statements about CPD. Statements d, e, f, and l are negative statements about CPD. The average score for the negative statements is 1.9. On average the respondents disagree with the negative statements about CPD.

4.3.3 Inquiry-based learning (IBL)

The next set of questions tested teachers on two aspects about IBL. The first set of eleven questions tested teachers' attitudes and beliefs about IBL, and the second set of fifteen questions tested teachers' reasons for difficulties in implementing IBL. As stated earlier IBL is mainly defined as a learner-centred way of learning content, strategies and self-directed learning skills (PRIMAS, 2011). The aim of IBL is to stimulate learners to develop a critical inquiring mind and problem-solving aptitude (Anderson, 2002; Llewellyn, 2005). The core value of an inquiry-based lesson is learners being able to develop their questions to examine, to engage in self-directed inquiry (diagnosing problems, formulating hypotheses, identifying variables, collecting data, documenting their work, interpreting and communicating results) and to work in collaboration with others (Anderson, 2002; Llewellyn, 2005; PRIMAS, 2011).

4.3.3.1 Teachers' attitudes and beliefs about inquiry-based learning

Teachers were then asked to indicate the extent they agree with 11 statements testing teachers' attitudes and beliefs about inquiry-based learning. Teachers had to indicate using a 4-point Likert scale ranging from strongly disagree to strongly agree the extent they agree with the statements. The table below shows the 11 items and the totals of the teachers' responses.

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Table 4.2: Teachers' attitudes and beliefs about IBL

	Strongly disagree	Disagree	Agree	Strongly agree
a. I would like to implement more IBL practices in my lessons.	0	0	4	7
b. IBL is important for my current teaching practice.	0	1	3	7
c. Successful IBL requires students to have extensive content knowledge.	0	5	3	2

d. IBL is not effective with lower-achieving students.	2	6	2	1
e. I see no need to use IBL approaches.	7	4	0	0
f. IBL is well suited to overcome problems with students' motivation.	0	1	8	2
g. IBL provides material for fun activities.	1	1	6	2
h. I already use IBL a great deal.	0	5	5	1
i. I would like to have more support to integrate IBL in my lessons.	0	0	5	6
j. IBL is well suited to approach students learning problems.	0	0	6	5
k. I regularly do projects with my students using IBL.	0	4	7	0

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a. All 11 of the respondents agree with the statement that they would like to implement more IBL practices in their lessons, with seven strongly agreeing and four agreeing with the statement. This shows a positive attitude and belief by teachers towards choosing inquiry as instructional strategy.
b. Ten of the respondents believe that IBL is important for their current teaching practice with seven strongly agreeing and three agreeing with the statement. One respondent disagrees with the statement.
c. Five respondents agree with the statement that successful IBL requires students to have extensive content knowledge, with three agreeing and two strongly agreeing. Five respondents disagree with the statement.
d. Two respondents strongly disagree and six disagree with the statement that IBL is not effective with lower-achieving students. Two respondents agree and one strongly agrees with the statement.

e. All 11 of the respondents disagree with the statement that they see no need to use IBL approaches, with seven strongly disagreeing and four disagreeing.
f. Ten respondents agree with the statement that IBL is well suited to overcome problems with students' motivation, with eight agreeing and two strongly agreeing. Only one respondent disagrees with the statement.
g. Eight respondents agree that IBL provides material for fun activities, with six agreeing and two strongly agreeing. One respondent strongly disagrees and one disagrees.
h. Five respondents agree and one strongly agrees with the statement that they already use IBL a great deal. Five respondents disagree with the statement. This was an admission by the respondents that IBL is not used a great deal.
i. Five respondents agree and six respondents strongly agree with the statement that they would like to have more support to integrate IBL in their lessons.
j. Six respondents agree and five strongly agree with the statement that IBL is well suited to approach students learning problems. This translates to the fact that all the respondents have positive attitude about IBL as a teaching strategy that can address learners' learning problems.
k. Four respondents disagree with the statement that they regularly do projects with their students using IBL. Seven respondents agree with the statement.

On a scale of 1 for strongly disagree to 4 for strongly agree the average score for the positive statements about IBL (statements a, b, f, g, h, i, j and k) is 3, 15. This is interpreted as saying the respondents agree with the positive statements about IBL. The average score for the negative statements about IBL is 2. This means that the respondents disagree with the negative statements about IBL.

4.3.3.2 Teachers' reasons for difficulties in implementing IBL.

Teachers were then asked to indicate the extent they agree with 15 statements to expose teachers' reasons for difficulties in implementing IBL. Teachers had to indicate using a 4-point Likert scale ranging from strongly disagree to strongly agree the extent they agree with the statements. Table 4.3 below shows the 15 items and the totals of the teachers' responses.

Table 4.3: Reasons for difficulties in implementing IBL

I have difficulties in implementing IBL, because...	Strongly disagree	Disagree	Agree	Strongly agree
a. The curriculum does not encourage IBL.	3	6	1	1
b. I don't have enough time to prepare IBL lessons.	1	5	4	1
c. I don't have adequate teaching materials.	0	2	8	1
d. IBL is not included in textbooks I use.	1	8	2	0
e. I don't know how to assess IBL.	1	7	3	0
f. I don't have access to any adequate CPD programs involving IBL.	0	7	3	1
g. I worry about students' discipline being more difficult in IBL lessons.	2	4	5	0
h. I don't feel confident with IBL.	2	5	4	0
i. I worry about my students getting lost and frustrated in their learning.	1	3	5	2
j. My colleague do not support IBL.	0	6	5	0
k. I think that group work is difficult to manage.	1	9	1	0
l. There is not enough time in the curriculum.	0	5	6	0

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m. I don't have sufficient resources such as computer, laboratory.	0	5	5	1
n. My students have to take assessments that don't reward IBL.	0	7	2	0
o. The number of students in my classes is too big for IBL to be effective.	1	3	7	0

(a) Three respondents strongly disagree and six disagree with the statement that the reason for difficulties in implementing IBL is because the curriculum does not encourage IBL. Nine of the participants do not see the curriculum as a reason for not implementing IBL. Only one agrees and one strongly agrees with the statement.

(b) One respondent strongly disagrees and five disagree with the statement that the reason for difficulties in implementing IBL is because they don't have enough time to prepare IBL lessons. Four respondents agree and one strongly agrees with the statement. Five of the respondents see the unavailability of enough time to prepare IBL lessons as a difficulty to implementing IBL.

(c) Two respondents disagree with the statement that the reason for difficulties in implementing IBL is that they don't have adequate teaching materials. Eight respondents agree and one strongly agrees with the statement. Nine of the respondents therefore cite inadequate teaching materials as the reason for the difficulty in implementing IBL.

(d) One respondent strongly disagrees and eight disagree with the statement that the reason for difficulties in implementing IBL is that IBL is not included in textbooks they use. Two respondents agree with the statement.

(e) One respondent strongly disagrees and seven disagree with the statement that the reasons for difficulties in implementing IBL is because they do not know how to assess IBL. Therefore eight of the respondents give the impression that assessment of IBL is not the reason for the difficulty in implementing IBL. Only three respondents agree with the statement.

(f) Seven respondents disagree with the statement that the reason for difficulties in implementing IBL is because they don't have access to any adequate CPD programs involving IBL. Therefore access to CPD programs involving IBL is not the reason for the difficulties in implementing IBL. Three respondents agree and one strongly agrees with the statement.

(g) Two respondents strongly disagree and four respondents disagree with the statement that the reason for difficulties in implementing IBL is that they worry about students' discipline being more difficult in IBL lessons. Five respondents agree with the statement.

(h) Two respondents strongly disagree and five disagree with the statement that the reason for difficulties in implementing IBL is because they don't feel confident with IBL. Four respondents agree with the statement.

(i) One respondent strongly disagrees and three disagree with the statement that the reason for difficulties in implementing IBL is that they worry about their students getting lost and frustrated in their learning. Five respondents agree and two strongly agree with the statement. Therefore with seven respondents agreeing with the statement, it indicates that more teachers do not choose IBL as a teaching strategy because they worry about their students getting lost and frustrated in their learning.

(j) Six respondents disagree with the statement that the reason for the difficulty in implementing IBL is that their colleagues do not support IBL. Five respondents agree with the statement.

(k) One respondent strongly disagrees and nine disagree with the statement that the reason for difficulties in implementing IBL is that they think that group work is difficult to manage. Ten respondents do not think that group work is difficult to manage. Only one respondent agrees with the statement.

(l) Five respondents disagree with the statement that the reason for difficulties in implementing IBL is that there is not enough time in the curriculum. Six respondents agree with the statement.

(m) Five respondents disagree with the statement that difficulty in implementing IBL is because they don't have sufficient resources such as computers, or a laboratory. Five agree and one strongly agrees.

(n) Seven respondents disagree with the statement that reasons for difficulties in implementing IBL are that their students have to take assessments that don't reward IBL. Therefore with seven respondents disagreeing with the statement against two respondents agreeing, the assessments that learners take are not seen as a reason for difficulties in implementing IBL.

(o) Seven respondents agree with the statement that the reason for difficulties in implementing IBL is that the number of students in their classes is too big for IBL to be effective. Only one respondent strongly disagrees, and three disagree with the statement. The big number of students in classes is therefore a common reason among the teachers for not implementing IBL.

In Table 4.4 below the reasons for difficulties in implementing IBL are arranged in the order of frequencies by combining strongly disagree with disagree and strongly agree with agree. A statement is considered popular if supported by seven participants out of the 11 participants.

Table 4.4: Reasons for difficulties in implementing IBL in order of frequencies.

I have difficulties in implementing IBL, because ...	Total agree	Total disagree
c. I don't have adequate teaching materials	9	2
i. I worry about my students getting lost and frustrated in their learning	7	2
p. The number of students in my classes is too big for IBL to be effective	7	4

The unavailability of adequate teaching materials was identified as the most common reason for difficulties in implementing IBL. Teachers' worry about their learners getting lost and frustrated in their learning, also contributes to the teachers not choosing IBL as a teaching strategy. The large number of learners in classes was also identified as demotivating teachers from choosing and using IBL in their classes.

Seven statements (a, d, e, f, h, k, and n) were commonly rejected as reasons for difficulties in implementing IBL. Table 4.5 shows the statements that respondents popularly ruled out as reasons for difficulties in implementing IBL.

Table 4.5: Statements not chosen as reasons for difficulties in implementing IBL

I have difficulties in implementing IBL, because ...	Total agree	Total disagree
a. The curriculum does not encourage IBL.	2	9
d. IBL is not included in textbooks I use.	2	9
e. I don't know how to assess IBL.	3	8
f. I don't have access to any adequate CPD programs involving IBL.	4	7
h. I don't feel confident with IBL.	4	7
k. I think that group work is difficult to manage.	1	10
n. My students have to take assessments that don't reward IBL.	2	7

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For the other statements the participants were divided into five and six respondents between agreeing and disagreeing with the statements. No clear judgement could therefore be made regarding these statements as reasons for difficulties in implementing IBL.

The questionnaire then asked teachers to comment on the main difficulties that hinder the implementation of IBL in their lessons. Nine of the respondents commented and their comments are listed in Table 4.6 below. Main concerns from their comments were highlighted, extracted and coded alphabetically. Similar concerns from different participants were assigned the same letter and therefore grouped into categories. Themes were then formulated from the categories.

Table 4.6. Mentioned difficulties that hinder the implementation of IBL

<table>
<tr><th>Comments</th><th>Categories/Codes</th><th>Themes</th></tr>
<tr><td>Due to the large number of learners in classes, it makes IBL difficult and also the current curriculum is too long such that you may not finish content on time</td><td>• large number of learners in classes (A)
• curriculum too long, may not finish content on time (B)</td><td rowspan="5">A. Large number of learners in classes
B. Not enough time within the curriculum
C. Inadequate teaching materials.
D. Poor language command
E. Time to prepare IBL lessons
F. Restricted funding to do research
G. Lack of opportunities to visit industries
H. Lack of support from schools and peers</td></tr>
<tr><td>Lack of resources and materials. Time resources being available sometimes it take time to get the resource and I end up teaching learners without the material</td><td>• lack of resources and materials (C)</td></tr>
<tr><td>Language is a big challenge to the learners</td><td>• language is a challenge (D)</td></tr>
<tr><td>Not enough time for IBL lesson preparation. No sufficient resources, apparatus and chemicals not available for practical work</td><td>• not enough time for IBL lesson preparation (E)
• no sufficient resources apparatus and chemicals (C)</td></tr>
<tr><td>Restricted funding on doing research affects the learning environment. Learners</td><td>• restricted funding on doing research (F)</td></tr>
</table>

do not get the opportunities to go to industries plants, manufacturing companies to actually see production the need for it	• learners do not get opportunities to go to industries plants (**G**)	
The number of students in class when is too big, does not allow effective learning to take place	• the number of students in class too big (**A)**	
There are **so many students in my classes** and **little resources especially textbooks** and other teaching materials	• so many students in classes (**A**) • little resources especially textbooks and other materials (**C**)	
There are too **many programs that are taking place at our school**. Most of the time I focus much on the MST academy programme. **I do not have time to sit down and plan my lessons**	• too many programs taking place (**B**) • do not have time to sit down and plan lessons (**E**)	
Time is one of them, **there isn't enough time to allow learners to discover themselves**	• there is not enough time to allow learners to discover themselves (**B**)	

otherwise they won't be able to finish the set curriculum. **Shortage of material** and **assistance in the form of personnel** like lab assistants and laboratory and equipment	• shortage of material (**C**) • shortage of assistance in the form of personnel(**H**)	

From the teachers' comments eight difficulties could be extracted with the shortage of teaching materials being the most mentioned difficulty. The large number of learners in classes and unavailability of adequate time within the curriculum to implement IBL were the next main difficulties mentioned by teachers. Teachers' comments were consistent with their responses as tabled in Table 4.4, where the lack of adequate teaching materials and the large number of learners in classes were identified as the main reasons for difficulties in implementing IBL lessons.

Lack of adequate time to plan for IBL lessons by teachers is also mentioned as a reason for the difficulty in implementing IBL. Poor command of the language of teaching and learning is another reason for the difficulty in implementing IBL. Other reasons mentioned include lack of support by the school and peers, lack of opportunities to visit industries by learners, and lack of funding for research aimed at exposing the reasons for the difficulties in implementing IBL and finding better and more effective teaching strategies.

4.3.4 Current practices at classroom level

The next set of questions was assessing current practices at classroom level for both the teachers and learners. Current practices which are mainly exposed by activities of both the teachers and learners during lessons are measured on six scales that focus on different aspects of teaching styles and the arrangement of the lesson and the aims of the lesson (PRIMAS, 2011). The six scales are:

- Frequency of exercises,

- Focus on real world applications,
- Relevance of learners' interactions and discussions,
- Frequency of experiments,
- Frequency of investigations,
- Role of hands-on activities.

These scales characterises envisaged teachers' and learners 'activities during an IBL focused lesson.

4.3.4.1 *Activities during lessons*

Teachers were asked to indicate the frequency with which learners are engaged in learning activities during their lessons. Analysis of the classroom activities as chosen by the teachers allowed for the classification of characteristic pattern of the teaching practices. Teachers were to respond to 21 activities by using 4 scales which are: never or hardly ever, in some lessons, in most lessons, and in almost all lessons, to indicate how often has each activity occurred during their lessons. Teachers' responses are as listed in Table 4.7 below.

Table 4.7: Activities during lessons

In my lessons ...	Never or hardly ever	In some lessons	In most lessons	In almost all lessons
a. I have my students working on their own, consulting a classmate from time to time.	0	8	3	0
b. I encourage my students to use only the methods I teach them.	5	3	2	1
c. I give my students the opportunity to choose which questions they tackle.	5	4	1	1

d.	I encourage students to work more slowly.	6	4		1
e.	I teach the whole class at once.	0	4	6	1
f.	I draw links between topics and move back and forth between topics.	0	6	1	4
g.	I am surprised by the ideas that come up in a lesson.	2	7	1	1
h.	I avoid students making mistakes by explaining things carefully first.	2	4	3	2
i.	I tend to follow the textbooks or worksheets closely.	0	4	7	0
j.	I try to teach each learner differently according to individual needs.	2	3	4	2
k.	I try to cover everything in a topic.	1	1	5	4
l.	I try to remove students fear about failure.	1	1	2	7
m.	I explain how a school maths/science idea can be applied to a number of different phenomena.	0	3	3	5
n.	I use the maths/science to help students understand the world outside school.	0	4	2	5
o.	I clearly explain the relevance of maths/science concepts to daily life.	0	3	3	5

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p. I enable students to make presentations.	0	5	3	3
q. I circulate and interact with students.	0	2	3	6
r. I discuss variations in data collected by students following their experiments.	1	3	4	3
s. I use questioning strategies to respond to students' questions.	0	5	3	3
t. I have students ask questions about maths/scientific phenomena addressed during experiments.	1	3	5	2
u. I have students engage in discussions among themselves.	1	5	3	2

In order to give an overview on how lessons are structured, the items are grouped in accordance with the six scales which measure characteristics of teaching practices (PRIMAS, 2011). The first scale, which covers items (a) to (l) measures the frequency of exercises (EXE). The frequency of exercises is the measure of how often the learners are actively involved in activities that help them to learn during a lesson. This is to measure whether the lessons are more teacher centred or more learner centred. The second scale, which covers items (m) to (o) reports on the frequency of teaching with a focus on application and on relationship to daily life (APP). These items measure how often within the lesson scientific concepts are linked to real life phenomena that are relevant to the learners. Items (p) and (q) measure the frequency of learners' interaction, focusing on discussion (INT). These items measure the extent of the interaction among learners within a lesson. Items (r) and (s) measure the frequency of discussion regarding experiments (EDI). These items measure the extent of discussion based on experiments between the teacher and the learners. Item (t) measures the frequency of practical activities with a focus on the hands-on aspect

(HON). This item measures the extent of learner engagement emanating from experiments. Item (u) captures the frequency of investigation (INV). This item measures the extent to which learners are involved in investigating particular phenomena through discussions among themselves. The average mean score for each scale was used to get a view of the structure of lessons. A three class model was used to classify the different teaching styles (PRIMAS, 2011):

- Traditional teacher oriented style
- Intermediate focused form of IBL
- Extremely learner and activity oriented style of teaching

The table below shows the six sub-scales and the averages of the teachers' responses.

Table 4.8: Current classroom activities

Sub scale	Statements covered	Definition	Average
EXE	(a) to (l)	Frequency of learners' engagement on exercises	2.4
APP	(m)to (o)	Applications and relationship of scientific concepts to daily life	3.2
INT	(p) to (q)	Frequency of learners' interactions	3.1
EDI	(r) and (s)	Frequency of discussions regarding experiments	2.8
HON	(t)	Frequency of practical activities focusing on hands-on aspects	2.7
INV	(u)	Frequency of learners' investigations of phenomena	2.5

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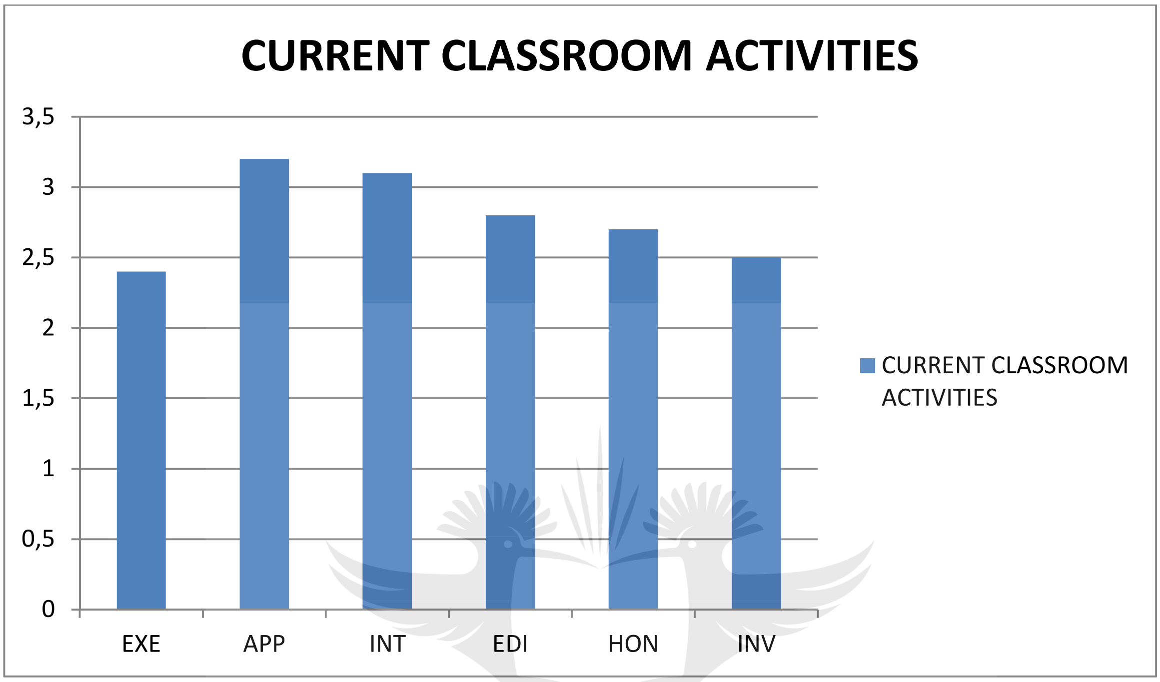
Figure 4.1 shows the averages for the scales on current classroom practices.

Figure 4.1: Graph showing averages of IBL activities in classrooms



The average on EXE is 2.4 and is below 2.5 which indicate a low frequency of learners' engagement on exercises during the lessons. Therefore, classroom activities are more teacher centred. The average on APP is 3.2 and is above 2.5 which indicates a greater level of focus on applications and relationship of scientific concepts to daily real life situations. The average on INT is 3.1 which indicate that teachers regard learners' interaction as a prevalent element of their lessons. The average for EDI is 2.8; this indicates that there is an intermediate level of discussion of experiments during lessons. The average for HON is 2.7 which indicates that hands-on experiments can be found in some lessons. The average for INV is 2.5. This also indicates that learners are given time and encouraged to conduct investigations only in some lessons.

4.3.4.2 ***Learners' activities during lessons***

Teachers were then asked to indicate the frequency of their learners doing inquiry-based activities during their lessons. Teachers had to respond to 11 activities by using

4 scales which are: never or hardly ever, in some lessons, in most lessons, and in almost all lessons, to indicate how often has each activity occurred during their lessons. Teachers' responses are as listed in Table 4.9.

Table 4.9. Inquiry-based activities during lessons

In my lessons my students ...	Never or hardly ever	In some lessons	In most lessons	In almost all lessons	Average score
a. Learn through doing exercises.	0	2	6	3	3.1
b. Start with easy questions and work up to harder questions.	0	2	5	4	3.1
c. Work collaboratively in pairs or small groups.	0	5	5	1	2.6
d. Are given opportunities to explain their own ideas.	1	3	3	4	2.9
e. Have discussion about the topics.	0	4	5	2	2.8
f. Do practical activities.	1	6	3	1	2.4
g. Draw conclusions from an experiment they have conducted.	0	6	3	2	2.6
h. Do experiments by following my instructions.	1	4	3	3	2.7

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i. Are allowed to design their own experiments.	5	2	3	1	2
j. Are asked to do an investigation to test out their own ideas.	3	3	3	2	2.4
k. Have opportunities to work with little or no guidance.	3	5	2	1	2.1

The averages of the scores for each item were then calculated. Using a scale of 1 to 4, where 1 represents never or hardly ever and 4 represents in almost all lessons. Meaning was then assigned to the averages of the scores.

(a) An average of 3.1 on item a indicates that teachers report that in their lessons learners learn through doing exercises in most of their lessons
(b) An average of 3.1 on item b indicates that teachers report that learners start with easy questions and work up to harder questions in most lessons.
(c) An average of 2.6 on item c indicates that in most of the teachers' lessons learners work collaboratively in pairs or small groups in most of the lessons.
(d) An average of 2.9 on item d indicates that learners are given opportunities to explain their own ideas in most of the lesson.
(e) An average of 2.8 in item e indicates that learners are given opportunities to have discussions about the topics in most of the lessons.
(f) An average of 2.4 in item f indicates that learners only do practical activities in some lessons.
(g) An average of 2.6 in item g indicates that learners are allowed to draw conclusions from experiment they have conducted in most lessons.
(h) An average of 2.7 on item h indicates that learners do experiments by following teachers' instructions in most lessons.
(i) An average of 2 in item i indicates that learners are only allowed to design their own experiments in some lessons.
(j) An average of 2.4 in item j indicates that only in some lessons learners are asked to do an investigation to test out their own ideas.

(k) An average of 2.1 in item k indicates that learners have opportunities to work with little or no guidance only in some lessons.

With averages above 2.5 in 7 of the items (item a, b, c, d, e, g, and h), it can be said that learners are engaged in inquiry-based activities in most of the lessons. With averages of less than 2.5 for 4 items (f, i, j, and k), means that learners are deprived of opportunities to carry out activities that involve doing practical activities, designing experiments, doing investigations to test their own ideas, and working with little or no guidance. Engagement on practical activities and doing experiments is only done in some lessons. Where learners are given opportunities to do experiment they follow the teachers' instructions as indicated by an average of 2.7 on item h.

4.4 PHYSICAL SCIENCES GRADE 10 LESSONS OBSERVATIONS

Three teachers among those who completed the questionnaire were identified for lesson observations. Each teacher was to be observed in two lessons. Teachers were not given any instructions by the researcher with regard to their lessons prior to the lessons and not given feedback after the lessons. The aim was to capture the normal behaviour of both the teachers and learners during Physical Sciences lessons. Teachers were encouraged to prepare and present their normal lessons as far as possible. The lessons observed were therefore normal lessons that represent teachers' and learners' behaviour during their lessons. The lessons were video recorded, transcribed and then analysed.

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It must be reported that this was the most challenging part of the study. First it was very difficult to get teachers who were willing to take part in this part of the research. Teachers were very reluctant to allow outsiders into their classrooms to observe them. The idea that their lessons will be video recorded added to this reluctance. All the teachers who completed the questionnaire indicated that it would be for the first time for their lessons to be observed and video recorded by an outsider. After thoroughly explaining to teachers the aim of the study, how and for what the results would be used, but mainly assuring them that the results would never be used against them, three teachers willingly agreed to take part in the study.

The video recorded and transcribed lessons were evaluated using the RTOP. RTOP was used as outlined in Chapter 3 above.

Table 4.10. Shows the five categories of the classification of the RTOP scores, which were used to categorise the observed lessons after evaluation.

Table 4.10. Categorisation of RTOP scores

RTOP Category	Typical RTOP score	Type of teaching
I	0-30	Straight lecture
II	31-45	Lecture with some demonstration and minor student participation
III	46-60	Significant student engagement with some minds-on as well as hands-on involvement
IV	61-75	Active student participation in the critique as well as the carrying out of experiments
V	76-100	Active student involvement in open-ended inquiry, resulting in alternative hypotheses, several explanations, and critical reflection
Source: (Ebert-May, Derting, Hodder, Momsen, Long & Jardeleza, 2011)		

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Categories I and II represent teacher-centred classrooms, and categories III–V represent classrooms that are learner-centred to varying extents (Ebert-May, et al., 2011).

4.5 RTOP SCORES FOR THE OBSERVED LESSONS

RTOP evaluates lessons on five categories as listed in table 4.11 below, and each category consists of five defining statements (Piburn & Sawada, 2000). Each of the defining statement is assessed on a 5-point Likert scale ranging from 0 (never occurred) to 4 (very descriptive). Each of the categories is cumulatively assessed out of a total score of 20 and each lesson is therefore assessed out of a total score of 100.

Table 4.11. RTOP categories

Category	Designation
1	Lesson Design and Implementation
2	Content: Propositional Pedagogic Knowledge
3	Content: Procedural Pedagogic Knowledge
4	Classroom Culture: Communicative Interactions
5	Classroom Culture: Student/teacher Relationships

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In assessing the observed lessons the focus was on identifying the five categories of inquiry-based lesson as indicated in the RTOP within the lesson. The scoring was based on the extent to which each item within categories could be describing the activities of both the teacher and learners within the lesson. Emphasis was on determining the extent to which inquiry-based strategies are employed during the lessons.

Three teachers were observed and two lessons were observed per teacher. In this analysis the teachers are assigned pseudonyms: Mr Malinga, Mr Mashabane, and Ms Hlophe.

4.5.1 Analysis of Mr Malinga's lessons

Mr Malinga was a senior teacher in the school with 24 years' teaching experience. The class had 33 learners with an equal mix of boys and girls. Both lessons were conducted in a building designated to be a laboratory but apart from the fitted tables and chairs, there was no laboratory equipment; even the water taps were dry. Learners were seated in rows behind the tables.

Table 4.12 and Table 4.13 below presents the analysis of both of Mr Malinga's observed lessons. Table 4.14 presents the summary of the RTOP scores for both the lessons.

Table 4.12. Analysis Mr Malinga's lesson 1 (Topic: Equations of motion)

CATEGORY/ITEMS	REMARKS	RATING
Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	The teacher made no effort to expose the learners' prior knowledge and preconceptions. This was evident from the statement "*without wasting time I will give you the equations of motion".* The teacher only asked learners to give definitions of concepts like velocity.	1
2. The lesson was designed to engage students as members of a learning community	Learners were only engaged in answering questions asked by the teacher. Questions were low order recall questions which mainly focus on definitions of concepts	1
3. In this lesson, student exploration preceded formal presentation.	There was no space and time given to learners to explore the topic before formal presentation. The teacher went straight into presenting.	0
4. This lesson encouraged students to seek and value alternative modes of	The teacher presented the equations of motion in one format only, there was no attempt to explore alternative modes.	0

investigation or of problem solving.		
5. The focus and direction of the lesson was often determined by ideas originating with students.	Every aspect of the lesson originated from the teacher's presentation. Learners only responded to the teacher's questions with no contribution to the direction of the lesson.	0
Content: Propositional Pedagogic Knowledge		
6. The lesson involved fundamental concepts of the subject.	The lesson covered fundamental concepts of the mechanics section of Physical Sciences. Equations of motion are critical in mechanics.	4
7. The lesson promoted strongly coherent conceptual understanding.	The presentation of the equations of motion, the definition of terms, and the applications of the equations in solving problems were all presented in a coherent way.	2
8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher explained the equations of motion well, the examples given were aimed at exposing the concept further to the learners. The teacher showed solid grasp of the subject matter.	3
9. Elements of abstraction (i.e., symbolic representations, theory building) were	Attempt was made to fully explain the symbols used in the equations of motion that represented physical quantities and the units used.	2

encouraged where it was important to do so.	However, the teacher made no effort to explain the derivation of the equations of motion or to explain how motion is represented by equations. There was also no attempt to link the equations of motions to graphs of motions which best represent motions.	
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	The problems given to learners to solve were based on real problems, hence the content was well connected to the real world. No attempt was made to link the content to other disciplines.	2
Content: Procedural Pedagogic Knowledge		
11 Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners were not given any opportunity to represent the content except by using the equations of motion to solve problems. They were only required to apply the equations of motion in solving problems.	1
12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	Learners were never given the opportunity to make predictions or to devise means of testing any hypotheses.	0

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13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	Learners were just following the teacher's instructions. The only engagement was in answering questions or attempting to solve the given problems.	1
14 Students were reflective about their learning.	There was no reflection on the part of the learners.	0
15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	Learners were never engaged in critically discussing the content.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	Learners were only discussing when solving problems. Learners only shared ideas of solving the given problems. All attempts were based on the information given prior by the teacher.	1
17. The teacher's questions triggered divergent modes of thinking.	Teacher's questions were simple recall questions mainly focusing on definitions of concepts.	1
18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	Learners only talked to each other when trying to solve the given activities. Learners will only talk to those closer to them, there were no discussions involving the whole class. Learners who presented their solutions on the board did so without	2

	talking to the class, they just wrote their solutions on the board.	
19. Student questions and comments often determined the focus and direction of classroom discourse.	Learners never asked the teacher any questions and comments made were only in response to the teacher's questions.	0
20. There was a climate of respect for what others had to say.	The learners showed great respect for the teacher. Learners were however very reserved and did not engage with each other. However, learners could freely respond to questions.	2
Classroom Culture: Student/teacher Relationship		
21. Active participation of students was encouraged and valued.	The teacher used questions to keep the learners active and involved during the presentation. Learners were further given a number of exercises to solve in consolidating the lesson.	2
22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	Learners were not given opportunities to find alternative solutions or strategies. The presentation was only aimed at being interpreted in the way presented by the teacher.	0
23. In general the teacher was patient with students.	The teacher allowed enough time for the learners to respond to all the questions he asked. He was never quick to give answers to questions	3

	even when learners struggled to give answers.	
24. The teacher acted as a resource person, working to support and enhance student investigations.	The teacher directed the lesson and provided all the information needed in the lesson. Learners were however denied the opportunity to explore and expose their prior knowledge.	1
25. The metaphor "teacher as listener" was very characteristic of this classroom.	Most of the talking in the lesson was done by the teacher. There were few instances where the teacher had to listen and only when learners were responding to questions. Learners never brought up their ideas.	1
TOTAL SCORE		27

Table 4.13. Analysis of Mr Malinga's lesson 2 (Topic: Waves, Sound and Light)

CATEGORY/ITEMS	REMARKS	RATING
Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	There was no attempt from the teacher to expose learners' prior knowledge and preconceptions.	0
2. The lesson was designed to engage students as	The teacher used questions throughout the lesson to engage learners. However, learners were just responding to the questions with no	2

	members of a learning community.	ideas of their own regarding the content.	
3.	In this lesson, student exploration preceded formal presentation.	There was no opportunity given to the learners to explore the topic before the formal presentation. The teacher took direct charge of the lesson and presented the content immediately.	0
4.	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	Learners were not encouraged or given the opportunity to seek for alternative modes of investigation or of problem solving.	0
5.	The focus and direction of the lesson was often determined by ideas originating with students.	The teacher was in charge of the lesson. The teacher controlled the learners' participation by continuously asking directing questions.	0
Content:	Propositional Pedagogic Knowledge		
6.	The lesson involved fundamental concepts of the subject.	The lesson involved waves, sound and light which are fundamental concepts in Physical Sciences.	4
7.	The lesson promoted strongly coherent conceptual understanding.	The teacher presented the lesson in a coherent manner. Questions were leading learners in building understanding of the concepts. The exercises given also helped the learners to understand the concepts. However, learners' prior conceptions were never recognised or addressed.	2

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	The teacher decided prior to the lesson how the learners must learn and learners were not given any opportunity to direct their own learning. The teacher decided what to be done, how and when during the lesson.	
8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher showed good understanding of the subject matter. The presentation of the concepts was logical and definition of terms was detailed.	3
9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	Apart from using symbols in the wave equation, the teacher relied heavily on words to explain even the abstract concepts about waves. No demonstrations were made even in areas were such could have helped, e.g. in the differentiation between transverse and longitudinal waves.	1
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	There was no connection with other content discipline and the real world. The teacher just mentioned at the beginning of the lesson that people interact with the wave phenomena on daily basis, but there was no connection shown during the lesson.	0
Content: Procedural Pedagogic Knowledge		

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11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners were never encouraged to use other means to represent the phenomena except responding to questions and attempting to solve the exercises given using the teacher's presented method.	0
12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	At no point were learners invited to make predictions and or hypotheses and devised means for testing them.	0
13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	Learners were only responding to leading questions from the teacher and only attempted to solve the given problems.	0
14. Students were reflective about their learning.	There was no opportunity for the learners to reflect on their learning.	0
15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	There was no intellectual engagement from the learners. Learners were very receptive of the teacher's ideas.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	Except when answering the teacher's questions there was minimal communication between learners.	1

17. The teacher's questions triggered divergent modes of thinking.	The teacher's questions were very direct and directed learners towards a single way of understanding and presenting the concept.	1
18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	There was minimal talk between and among the learners. Most learners' talking was directed to the teacher as a response to a question.	1
19. Student questions and comments often determined the focus and direction of classroom discourse.	In the entire lesson only one learner asked a question seeking clarity on displacement. There were no other questions from learners. Their only contribution to the lesson was in answering questions asked by the teacher.	0
20. There was a climate of respect for what others had to say.	Learners showed great respect for the teacher. On cases when the learners were talking there was respect from fellow learners.	2
Classroom Culture: Student/teacher Relationship		
21. Active participation of students was encouraged and valued.	Learners' participation was limited to answering questions and doing the exercises given by the teacher.	1
22. Students were encouraged to generate conjectures, alternative solution	There was no encouragement for the learners to generate alternatives solution strategies and ways of interpreting evidence. Learners were	0

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strategies, and ways of interpreting evidence.	expected solve the presented problems using mainly the format presented by the teacher.	
23. In general the teacher was patient with students.	The teacher allowed reasonable time for the learners to think and formulate answers to questions and to solve problems. The teacher was never quick to offer answers to difficult questions.	2
24. The teacher acted as a resource person, working to support and enhance student investigations.	The whole lesson relied on the teacher giving the learners information. The information given was never aimed at supporting learners in their investigations.	1
25. The metaphor “teacher as listener” was very characteristic of this classroom.	To a lesser extent the teacher was a listener only when the learners were responding.	1
TOTAL SCORE		22

Table 4.14: Total RTOP scores for Mr Malinga

Categories	Lesson 1 Categories score	Lesson 2 Categories scores	Average score
Lesson Design and Implementation	2	2	2
Content: Propositional Pedagogic Knowledge	13	10	11.5

Content: Procedural Pedagogic Knowledge	1	0	0.5
Classroom Culture: Communicative Interactions	5	5	5
Classroom Culture: Student/teacher Relationships	6	5	5.5
Total score	27	22	24.5

Mr Malinga's RTOP scores analysis

Both of Mr Malinga's observed lessons have RTOP scores below 30 (22 and 27) and are category I lessons. Both lessons are straight lectures. With an average of 24.5 Mr Malinga's lessons are teacher centred.

4.5.1.1 Lesson Design and Implementation

During the first lesson the teacher started the lesson by saying:

"Without wasting time I will give you the equations of motion that we are going to use"

The teacher's approach was focused on delivering the lesson and giving the learners the planned information. There was no regard for learners' prior knowledge and no effort was made to expose learners' preconceptions in the topic. The teacher's instructional approach reduced the learners to just recipients of information, learners were never engaged as members of a learning community. The entire lesson was driven and directed by the teacher.

4.5.1.2 Content: Propositional Pedagogic Knowledge

Both lessons addressed fundamental concepts in Physical Sciences and the arrangements and the order in which the information was presented promoted conceptual understanding. The equations of motion which were covered in the first lesson and the wave concept covered in the second lesson, are very important in the

Physical Sciences. The teachers' presentation of facts and concepts indicated that the teacher had a solid grasp of the subject matter. There was no incorporation of other forms of representation of the concepts in the lesson. The lesson was presented in a manner that promoted only one form of representing the information. There was minimal effort in both lessons to show connections with other content disciplines and/or real world phenomena.

4.5.1.3 Content: Procedural Pedagogic Knowledge

Both lessons were teacher-centred straight lectures and learners' were never involved in the lesson as envisaged by the inquiry-based approach. Learners were never engaged or encouraged to make predictions, estimations and/or hypotheses and devised means for testing them.

4.5.1.4 Classroom Culture: Communicative Interactions

As both lessons were straight lecture teacher-centred lessons, the teacher did most of the talking. Communication was one way, from the teacher to the leaners. Learners were never encouraged or directed towards divergent modes of thinking. There was no opportunity given to the learners to share ideas and talk to each other except when responding to the teacher's questions or when writing on the board. Most learners' talking was directed to the teacher and was mainly made by the whole class at once.

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4.5.1.5 Classroom Culture: Student/teacher Relationships

Learners were encouraged to participate actively only towards the end of both lessons when learners were working on the exercises given by the teacher. Learners were expected to solve the given problems by following the method given by the teacher. The teacher kept reminding the learners what he wanted to see in their approach. This was evident when the teacher said, "follow the steps written on the board and see if you cannot come up with the correct formula". Learners were not encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.

4.5.2 Analysis of Mr Mashabane's lessons

Mr Mashabane was a teacher with eight years' teaching experience in the same school. The school was one of the designated Maths, Science and Technology focus schools. The class had 46 learners. Learners were seated in rows with two learners per desk all facing the front of the class. The class had no teaching aids at all except the chalkboard, not even charts on the walls.

Table 4.15 and Table 4.16 below presents the analysis of both of Mr Mashabane's observed lessons. Table 4.17 presents the summary of the RTOP scores for both the lessons.

Table 4.15. Analysis of Mr Mashabane's lesson 1 (Topic: Newton's Law of Universal Gravitation)

CATEGORY/ITEMS	REMARKS	RATING
Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	There was no effort by the teacher to expose learners' prior knowledge and preconceptions. As seen from the statement "*let me start with the law, Newton's Law of Universal Gravitation",* to start the lesson. The teacher presented information to the learners without giving the learners opportunities to expose their prior knowledge.	0
2. The lesson was designed to engage students as members of a learning community.	Most of the talking was done by the teachers. The learners would at times respond to leading questions by the teacher as a group. Learners only answered questions asked by the teacher.	1

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3. In this lesson, student exploration preceded formal presentation.	There was no opportunity given to the learners to explore the topic before the formal presentation. The teacher started presenting right away.	0
4. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	Learners were never engaged in any investigation. The teacher presented the facts to the learners and the expectation was for the learners to listen and understand the concepts.	0
5. The focus and direction of the lesson was often determined by ideas originating with students.	Learners had no contribution in directing the lesson. The teacher directed the lesson by presenting the concepts to be learnt and occasionally asking questions.	0
Content: Propositional Pedagogic Knowledge		
6. The lesson involved fundamental concepts of the subject.	Newton's Law of Universal Gravitation is an important concept in Physical Sciences. The lesson therefore dealt with a fundamental concept.	4
7. The lesson promoted strongly coherent conceptual understanding.	The teacher presented the lesson in a coherent way. Concepts were presented logically and supported understanding of the whole content. However, the teacher missed an opportunity to use other forms of representation to enhance understanding. As a Maths, Science and Technology focus school, the	2

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	school had a reasonable supply of equipment. The teacher could have used other means to represent the concepts.	
8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher had a reasonable understanding of the concepts; however, the teacher's focus was mainly on the examination. The subject matter was presented with the focus on the examination. This limited the teacher to that which he felt was good for the examination.	3
9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	The teacher only used symbols in the equation to calculate the gravitational force. The entire presentation was based on the teacher talking and learners listening.	1
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	There was no attempt to connect the content to other content disciplines and the real world.	0
Content: Procedural Pedagogic Knowledge		
11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners were not encouraged or given opportunities to use a variety of means to represent phenomena. By stressing the examination learners were channelled into looking at the phenomena in the way presented by the teacher only	0

12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	There was no opportunity for the learners to make predictions, estimations and hypotheses and to devise means for testing them.	0
13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	Learners were reduced to listeners and on occasion responding to short straight questions. There was no engagement with the procedures by learners; the teacher directed the lesson	1
14. Students were reflective about their learning.	There was no reflection on the part of the learners.	0
15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	There was no intellectual rigour and criticism from the learners. Learners were occupied with trying to make meaning of the presented facts.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	There was no active engagement between learners. Learners would only answer questions from the teacher's questions and writing their answers on the board.	1
17. The teacher's questions triggered divergent modes of thinking.	The teacher's questions required short answers from the learners, e.g. yes or no. In most cases the learners would respond collectively as a group.	0

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18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	There was minimal learners' talk among themselves. Most of the learners talk was directed to the teacher and done in answering the teacher's questions.	1
19. Student questions and comments often determined the focus and direction of classroom discourse.	There were not much coming from the learners, but on a single case where the learner had a better idea about using the scientific calculator to solve a problem assisted the class and the teacher was very accommodating.	2
20. There was a climate of respect for what others had to say.	While the learners at times spoke simultaneously, which compromised whatever they were trying to say, the teacher was well in control of the class. However this compromised individual participation, because in almost all the teacher's questions learners would just talk simultaneously even if one of them was attempting the question.	1
Classroom Culture: Student/teacher Relationship		
21. Active participation of students was encouraged and valued.	The teacher tried to use questions throughout the lesson to actively engage the learners. However the questions used were of the same format and expected short answers from the learners.	2

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22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	There was no opportunity for the learners to generate alternative solution strategies. The teacher continuously reminded the learners how questions are asked in the examinations and how they should respond. This limited the thinking of the learners to only the format presented by the teacher.	0
23. In general the teacher was patient with students.	The teacher showed patience when dealing with the learners' responses. Reasonable time was allocated to the learners to formulate their responses. The teacher was also willing to consider every attempt by any learner.	2
24. The teacher acted as a resource person, working to support and enhance student investigations.	All the information regarding this topic was supplied by the teacher. The teacher's information was not used as a resource to support and enhance learners' investigations.	0
25. The metaphor "teacher as listener" was very characteristic of this classroom.	There were signs that the teacher was willing to listen to learners' ideas. This is evident in the teacher accepting the solution presented by the learner in solving a given problem.	2
TOTAL SCORE		21

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Table 4.16. Analysis of Mr Mashabane's lesson 2 (Topic: Geometric optics)

CATEGORY/ITEMS	REMARKS	RATING
Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	The teacher tried to invite learners to share their prior knowledge. This was evident when the teacher after mentioning that the lesson will be about light, he asked learners to mention anything they know about light. Before introducing the concepts reflection and refraction, learners were asked again to share with the class what they knew about these concepts. However the teacher missed an opportunity to guide and support the learners in exposing their prior knowledge and preconceptions; when learners could not say anything about light the teacher could have guided the learners instead of giving them the answers.	2
2. The lesson was designed to engage students as members of a learning community.	The teacher did most of the talking during this lesson. Learners were occasionally expected to respond to short questions and in most instances they responded as a group all at once.	1
3. In this lesson, student exploration preceded formal presentation.	While the teacher tried to invite learners to share their views about concepts before formal presentation,	1

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	there was no effort in helping and guiding learners to explore the topic. Questions asked were mostly definitions based.	
4. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	There were efforts to assist and encourage learners to seek alternative modes of investigations or problem solving.	0
5. The focus and direction of the lesson was often determined by ideas originating with students.	Learners only responded to the teacher's questions, there was no space and opportunity for the learners to initiate discussions or to bring new ideas.	0
Content: Propositional Pedagogic Knowledge		
6. The lesson involved fundamental concepts of the subject.	Geometric optics is a fundamental concepts in Physical Sciences and it helps in the understanding of light as a natural phenomenon.	4
7. The lesson promoted strongly coherent conceptual understanding.	The lesson was presented logically, concepts were introduced gradually and logically. The use of leading questions help in keeping the learners in touch of the lesson. However only one form of presentation was used, the telling method. Learners were reduced to just recipients of the information. Learners were never	2

	engaged in activities that enhanced conceptual understanding.	
8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher showed a good understanding of the subject matter.	3
9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	The teacher tried to draw ray diagrams on the board to show the concepts of reflection and refraction. This assisted in learners making meaning of the concept. As a Maths Science and Technology school, the teacher could have done more in representing the concepts in the form of demonstration or asking learners to conduct an investigation.	2
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	The tried to make connections with the real world by using daily lives examples e.g. reflections on mirrors. Other than the few examples there was no evidence of the connection of the concept with other content disciplines and the real world.	1
Content: Procedural Pedagogic Knowledge		
11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners were only limited to answering teacher's questions. They were only required to represent the phenomena in the way presented by the teacher.	0

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12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	At no point were learners asked to make predictions or hypotheses and devise means for testing them.	0
13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	Learners were never involved in assessing the procedures, because the only procedure was that designed by the teacher and learners were just recipients of information who at times were only expected to copy notes on the board.	0
14. Students were reflective about their learning.	There was never a chance or encouragement for the learners to reflect about their learning.	0
15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	Learners were just following the presentation as presented by the teacher and copying notes from the board. There was no constructive engagement with the concept and no challenging ideas were presented by the learners.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	There was little engagement between the learners. All the talk was between the teacher and the class as a whole. Learners would only speak when answering teacher's questions	0

17. The teacher's questions triggered divergent modes of thinking.	The teacher's questions were short leading questions which directed learners to see and present the concept in only the way presented by the teacher.	1
18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	There was very little talk between the learners; learners would be seen talking to each other in between the teacher's questions, but such discussions were never encouraged and learners could not engage the whole class.	1
19. Student questions and comments often determined the focus and direction of classroom discourse.	Learners never asked any questions and made no comments in the entire lesson. They only responded to the questions presented by the teacher.	0
20. There was a climate of respect for what others had to say.	The learners respected the teacher who did most of the talking. They also respected the few learners who answered questions individually. In most cases the learners would talk collectively as a group.	1
Classroom Culture: Student/teacher Relationship		
21. Active participation of students was encouraged and valued.	Learners were just reduced to a group that responded to questions and taking notes. The teacher did most of the talking.	1

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22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	There were opportunities and learners were not encouraged to generate alternative solution strategies and ways of interpreting evidence.	0
23. In general the teacher was patient with students.	The teacher seemed more concerned about completing the whole lesson as planned. The teacher hastily gave answers on questions when learners took a little longer to respond. E.g. on asking learners to say anything about light, the teacher was quick to tell learners about the speed of light instead of giving the learners time and support for them to think and present their ideas.	1
24. The teacher acted as a resource person, working to support and enhance student investigations.	All the information in the lesson came from the teacher, but it was never used to support and enhance learners' investigations. Learners were never encouraged to conduct any investigation.	0
25. The metaphor "teacher as listener" was very characteristic of this classroom.	Because most of the talking came from the teacher, there was little the teacher could listen to. But on the few occasions learners were speaking the teacher was very accommodating.	1
TOTAL SCORE		22

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Table 4.17: Total RTOP scores for Mr Mashabane

Categories	Lesson 1 Categories score	Lesson 2 Categories scores	Average score
Lesson Design and Implementation	1	4	2.5
Content: Propositional Pedagogic Knowledge	10	12	11
Content: Procedural Pedagogic Knowledge	1	0	0.5
Classroom Culture: Communicative Interactions	5	3	4
Classroom Culture: Student/teacher Relationships	4	3	3.5
Total score	21	22	21.5

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Mr Mashabane's RTOP scores analysis

Both of Mr Mashabane's lessons had a score of less than 30 (21 and 22), and are therefore category I lessons. They were also straight lectures which were highly teacher centred.

4.5.2.1 Lesson Design and Implementation

The lessons were straight lectures and there was no respect for the learners' prior knowledge and preconceptions. From the beginning of the lesson the teacher bombarded the learners with information. There was no effort by the teacher to engage the learners as members of a learning community. Learners were not given an opportunity to explore the topic before the formal presentation by the teacher. The learners were made to focus on writing notes and made no contribution to the direction of the lessons.

4.5.2.2 ***Content: Propositional Pedagogic Knowledge***

Both lessons treated fundamental concepts in Physical Sciences, Newton's Law of Universal Gravitation and light. The teacher emphasised the ability to answer the examination questions in the format he presented. The lessons were examination oriented. There was no connection with other content disciplines and/or real world phenomena.

4.5.2.3 ***Content: Procedural Pedagogic Knowledge***

Both lessons had none of the key components of an inquiry-based lessons. Learners were not given an opportunity to use a variety of means to represent phenomena. There were no activities or encouragements for the learners to make predictions, estimations and/or hypotheses and devise means for testing them.

4.5.2.4 ***Classroom Culture: Communicative Interactions***

There was no chance for the learners to express their ideas and there was no sharing of ideas between the learners. Learners were consistently reminded of how to present the answers to similar questions during the examinations. This created the impression that there is only one acceptable way of presenting these concepts. There was therefore less talk between and among the learners, on very few occasions learners would respond to the teacher's questions and in most cases as a group.

4.5.2.5 ***Classroom Culture: Student/teacher Relationships***

Throughout the lessons the teacher would use statements like "hey guys and ladies I am not going to write the final examination you are the ones who are going to write". These statements were very intimidating to the learners and negatively affected the participation of the learners. Learners were discouraged from generating alternative solution strategies and ways of interpreting evidence.

4.5.3 Analysis of Ms Hlophe's lessons

Ms Hlophe was a relatively new teacher with one year's teaching experience. Her class had 41 learners. The class had no teaching support materials. In both observed lessons it took some time before the learners would settle down for the lesson to start. Ms Hlophe tried to engage the learners going to an extent of shouting to some boys, but they would take time to respond for her to start with the planned lesson. Even while the lesson was continuing the boys would at some point cause some disturbances.

Table 4.18 and Table 4.19 below presents the analysis of both of Ms Hlophe's observed lessons. Table 4.20 presents the summary of the RTOP scores for both the lessons.

Table 4.18. Analysis of Ms Hlophe's lesson 1(Topic: Chemical Bonding)

CATEGORY/ITEMS	REMARKS	RATING
Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	The lesson was started by revising the previous lesson. There was therefore a connection between the previous lesson and the lesson to be presented. However, the teacher's focus was on what she had taught the learners during the previous lesson. Learners were mainly expected to recall given information. There was no effort to expose their prior knowledge in the content to be taught.	1
2. The lesson was designed to engage students as	Learners were given a fair chance to participate during the lesson. The teacher talked to all the learners as she was walking around when	2

members of a learning community.	learners were busy with a given activity.	
3. In this lesson, student exploration preceded formal presentation.	Learners were not given the opportunity to explore the topic before formal presentation by the teacher.	0
4. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	There was no opportunity for the learners to seek and value alternative modes of investigation or problem solving.	0
5. The focus and direction of the lesson was often determined by ideas originating with students.	All the information presented in the lesson came from the teacher. Learners were only responding to the teacher's questions, which in most cases they responded as a group.	0
Content: Propositional Pedagogic Knowledge		
6. The lesson involved fundamental concepts of the subject.	Lewis diagrams of atoms and chemical bonding is central in the chemistry part of Physical Sciences.	4
7. The lesson promoted strongly coherent conceptual understanding.	Concepts within the lesson were presented logically and a reasonable time would be spent on each item with reasonable examples to foster conceptual understanding; e.g. the Periodic Table was taught before presenting the Lewis diagrams of atoms.	3

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8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher had a good understanding of the subject matter. She was very detailed in her presentation. She gave reasonable examples in each of the concepts covered.	4
9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	The teacher was very thorough and detailed in presenting the Lewis diagrams of atoms representing valence electrons by dots or crosses. However models could have been used to further show bonding of atoms.	2
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	There was no evident connections with other content disciplines and the real world phenomena	0
Content: Procedural Pedagogic Knowledge		
11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners had no opportunity to use variety of means to represent the phenomena. They only knew the method used by the teacher.	0
12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	Learners made no predictions, estimations or hypotheses and never devised means for testing any prediction. The lesson never encouraged learners to engage in these activities.	0

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13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	Learners were reduced to recipients of information. They only responded collectively to confirmatory questions asked by the teacher during lessons.	1
14. Students were reflective about their learning.	There was no reflection of the learning of the learners	0
15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	Learners were never engaged beyond just receiving the content and reproducing what they have learnt.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	The only communication was between learners sitting next to each other when attempting the given questions. There was no sharing of ideas between the learners in the class. Some learners lost interest in the lesson and were seen sleeping during the lesson.	1
17. The teacher's questions triggered divergent modes of thinking.	The teacher only asked questions which required the learners to confirm what she was saying. Learners were asked only to confirm concepts in question during the lesson. In almost all the questions learners responded as a group.	0

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18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	Most of the talking during the lesson was done by the teacher. Learners mostly responded as a group and their responses were directed to the teacher. Some learners were talking only to draw the teachers' attention and they would say things not related to the subject matter which was addressed. Talking among the learners was limited to talking between learners seated next to each other on some occasions while attempting given activities.	1
19. Student questions and comments often determined the focus and direction of classroom discourse.	There were no questions asked by the learners and learners comments were in most cases responses to the teacher's questions. The teacher was in control of what went on in the class.	0
20. There was a climate of respect for what others had to say.	There were elements of disrespect from some of the boys, like the one who came late to class. Others would just talk and try to disrupt the class; other learners decided to sleep in the middle of the lesson. The teacher spent time talking to the learners during the lesson.	1
Classroom Culture: Student/teacher Relationship		

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21. Active participation of students was encouraged and valued.	The teacher tried to encourage the learners and to involve them during the lesson, however their involvement was limited to them answering questions.	1
22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	Learners did not generate conjectures, alternative solution strategies, and ways of interpreting evidence	0
23. In general the teacher was patient with students.	The teacher would lose her temper sometimes when addressing the unruly boys. However the teacher explained concepts to the class patiently.	1
24. The teacher acted as a resource person, working to support and enhance student investigations.	All the information in the lesson was supplied by the teacher. Learners were, however, never introduced to conducting investigations, they just received the information.	0
25. The metaphor "teacher as listener" was very characteristic of this classroom.	On the few occasions were the learners spoke the teacher was willing to listen. Most of the time it was the teacher talking	1
TOTAL SCORE		22

Table 4.19. Analysis of Ms Hlophe's lesson 2 (Topic: Ionic Bonding)

CATEGORY/ITEMS	REMARKS	RATING

Lesson Design and Implementation		
1. Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	The lesson started by doing corrections for homework given in the previous lesson. This assisted the teacher to expose learners' knowledge and address learners' preconceptions inherent regarding Lewis structures of atoms which was to assist in the topic to be taught. The teacher encouraged learners to share what they have written with the class.	3
2. The lesson was designed to engage students as members of a learning community.	The first part of the lesson was driven by learners giving feedback to the teacher and the other learners on their homework. The teacher mainly supported and guided the learners by using questions and giving correct information. However, during the presentation of the lesson the teacher presented all the information and the learners were reduced to just taking notes and mostly responding to the teacher's questions as a group.	2
3. In this lesson, student exploration preceded formal presentation.	The teacher presented the information to the learners by occasionally asking confirmatory questions where learners responded as a group. Learners were not given the opportunity to explore the topic before it was presented.	0

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4. This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	There was no opportunity or guidance for the learners to seek and value alternative modes of investigation or of problem solving.	0
5. The focus and direction of the lesson was often determined by ideas originating with students.	The entire direction of the lesson was directed by the teacher with little input from the learners.	0
Content: Propositional Pedagogic Knowledge		
6. The lesson involved fundamental concepts of the subject.	Lewis diagrams of atoms and the ionic bonding are fundamental concepts of Physical Sciences.	4
7. The lesson promoted strongly coherent conceptual understanding.	There was logical presentation of the concepts, starting from correcting the homework through the presentation. There was logical connection between concepts which helps coherent conceptual understanding. However the use of models to illustrate bonding or showing pictures on charts which were available, would have assisted the learners to understand the concepts.	2
8. The teacher had a solid grasp of the subject matter content inherent in the lesson.	The teacher displayed a solid grasp of the subject matter. There was a sense of confidence from the teacher while presenting the lesson. Concepts were thoroughly explained.	3

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9. Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	The only representation used was the Lewis diagram of atoms and showing the bonding. The teacher also emphasised the use of correct symbols for all elements in the Periodic Table.	2
10. Connections with other content disciplines and/or real world phenomena were explored and valued.	There was no direct connection with other content disciplines and real world phenomena were not explored.	0
Content: Procedural Pedagogic Knowledge		
11. Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	Learners were only taught only one way of representing the atoms and the bonding. Learners were not encouraged or guided to find other means of representing ionic bonding.	1
12. Students made predictions, estimations and/or hypotheses and devised means for testing them.	Learners had no opportunity to make any predictions, estimations and/or hypotheses and devise means for testing them.	0
13. Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	There was no engagement of learners in critical assessment of procedures. The teacher directed the lesson. No investigation was done.	0
14. Students were reflective about their learning.	There was no reflection of the learning on the part of the learners.	0

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15. Intellectual rigour, constructive criticism, and the challenging of ideas were valued.	Learners focused on writing notes and would from time to time just respond to the teacher's questions. There was no constructive criticism and no challenging questions from the learners.	0
Classroom Culture: Communicative Interaction		
16. Students were involved in the communication of their ideas to others using a variety of means and media.	Learners were encouraged to write their ideas on the board during the marking of the homework and in doing the activities given during the lesson to communicate their ideas. They also verbally responded to the teacher's questions.	1
17. The teacher's questions triggered divergent modes of thinking.	The teacher's questions were never aimed at triggering divergent modes of thinking. The questions were just aimed at making the learners confirm hearing what the teacher has presented and in the way the teacher has presented it.	0
18. There was a high proportion of student talk and a significant amount of it occurred between and among students.	The teacher did most of the talking during the lesson; the learners were only responding to the teacher's questions or doing the activities given. Most of the talking was between the teacher and the learners. There was less talk between and among the learners.	1

19. Student questions and comments often determined the focus and direction of classroom discourse.	Learners never asked any questions and their comments were only as responses to the teacher's questions. The learners had no influence in the direction of the classroom discourse.	0
20. There was a climate of respect for what others had to say.	The teacher had to do a lot of control and discipline to get the class in order. In each case the teacher succeeded in keeping order and protecting learners who wanted to talk. At times the teacher needed to raise her voice for the learners to respond as instructed, especially to afford others an opportunity to talk.	1
Classroom Culture: Student/teacher Relationship		
21. Active participation of students was encouraged and valued.	The teacher tried to invite the learners during the lesson to participate, but there was no planned learner engagement except the exercises at the end of the lesson.	1
22. Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	Learners never generated conjectures, alternative solution strategies, and ways of interpreting evidence.	0
23. In general the teacher was patient with students.	The teacher appeared angry and agitated when addressing learners' failure to respond to her questions. The teacher shouted at some learners	1

	for talking while she was talking. The teacher never lost focus of the lesson even when at times some learners were provoking her.	
24. The teacher acted as a resource person, working to support and enhance student investigations.	Even though all the information came from the teacher, the teacher never acted as a resource to support learners' investigations. Learners did not conduct any investigation.	0
25. The metaphor "teacher as listener" was very characteristic of this classroom.	The teacher spent most of the lesson talking; only on few occasions did she listen patiently and assist the learners.	1
TOTAL SCORE		23

Table 4.20: Total RTOP scores for Ms Hlophe

Categories	Lesson 1 Categories score	Lesson 2 Categories scores	Average score
Lesson Design and Implementation	3	5	4
Content: Propositional Pedagogic Knowledge	13	11	12
Content: Procedural Pedagogic Knowledge	1	1	1
Classroom Culture: Communicative Interactions	3	3	3

Classroom Culture: Student/teacher Relationships	2	3	2.5
Total score	22	23	22.5

4.5.4 Ms Hlophe's RTOP scores analysis

Ms Hlophe's lessons were straight lectures which were highly teacher centred. Both lessons' RTOP scores were below 30 and were therefore category I lessons.

4.5.4.1 Lesson Design and Implementation

The teacher tried to link the lessons with the previous lessons by asking questions on what the previous lesson covered and by doing corrections of a homework which was based on work covered in the previous lesson. Working on the homework assisted in exposing learners' preconceptions on the content covered in the previous lessons. However learners were not given a chance to expose their prior knowledge on what was still to be done in the lessons.

4.5.4.2 Content: Propositional Pedagogic Knowledge

Both lessons involved fundamental concepts of Physical Sciences. Representation of atoms and chemical bonding are critical concepts in understanding chemical reactions. The teacher presented the concepts in a way that promoted coherent understanding. However the teacher missed an opportunity to use other forms of representation like using models, which could have promoted strongly coherent conceptual understanding. The teacher displayed solid grasp of the subject matter content presented.

4.5.4.3 Content: Procedural Pedagogic Knowledge

The teacher presented and encouraged only one form of representation of the content presented. There was no opportunity for the learners to make any predictions, estimations and/or hypotheses and devise means for testing them. There was no active engagement of the learners in thought-provoking activity involving critical assessment. Activities given were similar to the examples given by the teacher, and this required learners to employ the same approach in solving them. There was no reflection from the learners regarding their learning.

4.5.4.4 ***Classroom Culture: Communicative Interactions***

The teacher tried to engage the learners in between doing activities, but there was never a healthy discussion. The teacher would ask what the learner was doing and how, but in most cases learners would fail to explain or argue their ideas. There was also no active talk between and among the learners. The focus and the direction of the classroom discourse was determined by the teacher.

4.5.4.5 ***Classroom Culture: Student/teacher Relationships***

Learners' participation was only as far as writing notes, and doing the activities given by the teacher. There was therefore no attempt from the learners to generate conjectures, alternative solution strategies, and ways of interpreting evidence. The teacher provided all the information during the lessons, and this reduced learners to just recipients of the given information.

All of the six observed lessons as assessed above were found to be straight lecture type of lessons. All the lessons were more teacher centred and learners were reduced to just taking notes and following instructions in doing the exercises designed by the teacher. Learners were instructed on each activity, there was no room for the learners' ideas in the lessons. In all of the lessons inquiry was never incorporated into the teaching and learning. Teachers did not choose and use inquiry as a teaching strategy even though it is the preferred strategy as stipulated in the Curriculum Statement.

4.6 ANALYSIS OF DOCUMENTS

Copies of the lesson plans of all the six lessons which were observed, were also requested from the teachers and analysed. Learners' workbooks were also checked to verify activities that learners are normally engaged on.

4.6.1 Lesson plan analysis

Analysis of lesson plans and gaining a clear picture of what the teachers planned to do was necessary in a quest to fully understand classroom instructions. Lesson plans were assessed to identify whether, in planning, teachers did explicitly include the five main features of an inquiry-based teaching and learning (Campbell, Abd-Hamid & Chapman, 2009):

(a) Framing a research question: this category focuses on the extent to which learners are responsible for framing their own research questions during investigation.
(b) Designing investigations: this category focuses on the extent to which learners are responsible for designing their own procedures for conducting investigation.
(c) Conducting investigations: this category focuses on the extent to which learners are responsible for conducting or carrying out the procedures.
(d) Collecting data: this category focuses on the extent to which learners are responsible for making decisions about data collection during investigations.
(e) Drawing conclusions: this category focuses on the extent to which learners are responsible for drawing conclusions during investigations.

The focus of the lesson plans analysis was on finding evidence of the teachers' intention of employing inquiry-based approaches. Such evidence would include:

- A plan to engage learners in exploring and observing a particular phenomenon of interest. This will include the teacher preparing the first question to be asked to raise the learners curiosity about the topic to be addressed (PRIMAS, 2011).
- An explicit plan to use questions that encourage thinking and reasoning, to engage learners in constant discussions and offer direction and support (Ramnarain, 2011).
- The lesson plan will be assessed to find out if the teacher has planned to allow the learners time to investigate the topic at hand, and be allowed and encouraged to share their findings (Ramnarain, 2011).
- Lesson plans will also be checked to find out whether the teacher has planned to use practical experiments to further clarify the concepts to be taught (Bybee, et al., 2006).

Analysis of the lesson plans was therefore aimed at revealing teachers' choices of instructional strategies before getting into the classes. This will reveal the extent to which teachers value and choose inquiry as an instructional strategy. The extent to which teachers choose inquiry as a teaching strategy and incorporate it in their lesson plans will expose teachers' attitudes and beliefs about inquiry. Only the lesson plans of the observed lessons were analysed and the results are as shown in table 4.21 below.

Table 4.21: Analysis of lesson plans

Teacher	LESSON TOPIC	Framing research question	Designing investigation	Conducting investigation	Collecting data	Drawing conclusion
Mr Malinga	Equations of motion	none	none	none	none	none
	Waves, sound and light	none	none	none	none	none
Mr Mashabane	Newton's Law of Universal Gravitation	none	none	none	none	none
	Geometric optics	none	none	none	none	none
Ms Hlophe	Chemical bonding (covalent bonding)	none	none	none	none	none
	Chemical bonding (ionic bonding)	none	none	none	none	none

In all the lesson plans there was no explicit planning to engage the learners in inquiry-based activities. Teachers did not plan to use inquiry as a pedagogical strategy in their classrooms. There was no evidence in the lesson plans to engage learners in inquiry-based activities. The lesson plans listed the information to be given to the learners, which confirmed what was observed during lessons observations. Teachers' plans were to disseminate information to the learners as quickly as possible and learners were to passively receive the information.

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4.6.2 Learners' workbooks analysis

Learners' workbooks were analysed to find evidence of learners' engagement in the five main features of inquiry-based teaching and learning (Campbell, Abd-Hamid & Chapman, 2009). All the activities recorded in the learners' workbooks were consistent with the activities given to the learners during the observed lessons. The activities only asked learners to recall and apply at lower level the learned concepts as indicated in the following activities extracted from three of the observed lessons:.

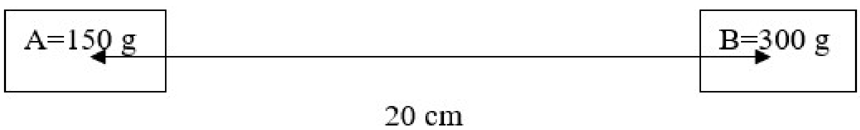
Mr Malinga after the lesson on equations of motion gave the learners the following classwork:

A minibus is travelling at 15 m/s. when a robot 30 m away changes to orange the driver brakes hard to stop in time. Calculate his acceleration.

The learners needed to remember the equations of motion as presented by the teacher, and employ the same approach as given by the teacher to solve the problem. Learners were never engaged in any of the features of inquiry-based teaching and learning.

Mr Mashabane gave the following activity when teaching Newton's Law of Universal Gravitation:

'*Let's call this one maybe example no 2. Let me say we have got maybe two bricks, the first brick has the mass of 150 g and the other one brick has the mass of 300 g and the distance from their centres is 20 cm.'*



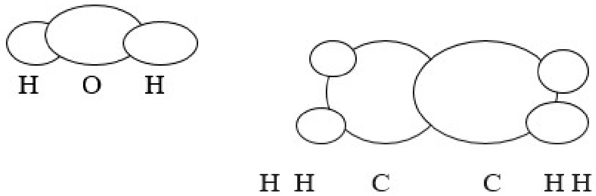
'Then they say calculate the force which brick A exert on brick B. Who can do that? Find the force between these blocks. Who can calculate the force?'

This activity also required learners to recall the formula and substitute the given data to find the force. There were no activities which engaged learners with the inquiry-based teaching and learning features.

Ms Hlophe after the lesson on representing atoms using Lewis diagrams and covalent bonding gave learners the following homework:

CLASSWORK

1. *Draw the Lewis diagram for the chlorine gas (Cl_2) and methane (CH_4).*
2. *Consider these electron diagrams:*



(a) Draw the Lewis diagram for each element

(b) Give the formula for the molecule

(c) How many electrons surround each O and H?

The homework also required learners to recall information given to be able to find the solution. The learners had to recall representing molecules using Lewis diagrams as presented by the teacher. Again there was no engagement on the features of inquiry-based teaching and learning.

All the activities were low order recall exercises and learners were never engaged in any of the inquiry-based features.

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4.7 INTERVIEWS WITH GRADE 10 PHYSICAL SCIENCES TEACHERS

The last part of data collection was conducting interviews with the three teachers whose lessons were observed. Interviews were conducted immediately after observation because the interviews were mainly based on the observed lessons. Interviews were conducted in the same classrooms where the teaching was done. While the interviews were recorded, the environment was made to be as informal as possible so that teachers would feel comfortable.

The interviews consisted of a set of five open-ended questions which focused on five areas of teaching and learning: The teacher's instructional strategy; the teacher's chosen instruction strategy and learners' understanding of the subject content; the teacher's chosen instruction strategy and the development of learners' thinking skills; factors influencing teachers' choice of instructional strategy; and the impact of CPD on the teacher's instructional strategy (Wainwright, Flick & Morrell, 2003). The interview protocol was designed by the Oregon Collaborative for Excellence in the Preparation of Teachers (OCEPT) Teacher Interview Protocol (O-TIP) (Wainwright, Flick & Morrell, 2003). O-TIP was designed based on the RTOP and it was aimed to prompt broad discussion of classroom practices (Wainwright, Flick & Morrell, 2003).

From the teachers' interview responses critical statements were highlighted and extracted to formulate themes.

Table 4.22: Teachers' interviews

QUESTION	Mr Malinga	Mr Mashabane	Ms Hlophe	THEMES
The current Physical Sciences statement prescribes the use of scientific inquiry in the teaching of Physical Sciences. What do you understand by the prescription of inquiry in the teaching of Physical Sciences?	I think the people who drafted this policy do not understand what is happening on the ground. We have **no laboratories**, **no equipment** and **the classes are overcrowded** how can we conduct experiments all the time?	Inquiry needs time and on the other hand one has to complete the schedule and be at par with the pace setter. It is difficult to find time to conduct investigations.	Sometimes I try to engage these learners on experiments before we discuss a concept but **these learners do not have the required skills**. I end up doing everything myself. **Some of these learners they just don't care.**	• No laboratories • Overcrowded classes • Time allocated in the curriculum not enough • Curriculum to be completed • Lack of skills by learners • Learners demotivated
How does the instructional method you have chosen	These **learners do not have textbooks** or any other source of	This method is effective because it allows me to **finish the**	Taking these learners slowly through the content and	• No learning materials

support development of content understanding?	information. So it's best I give them everything and they write notes so that they will have something to study.	**schedule on time** so that these learners **won't fail the tests or examinations.**	giving them notes is the only best method I **can use to help these learners.**	• Passing of standardised tests • Slow learners
How does your instruction support development of thinking?	If they have something to read, then their thinking can be improved, I also give them a **lot of written exercises.**	With all the notes I give them and the training I give them, they normally do well in **tests and examination.**	These **learners are struggling** it is therefore better that I give them some hope by giving them notes and **asking them easy questions**. I also assist them a lot.	• Reading and written work for learners • Passing of standardised tests • Motivation by easy questions
Besides the understanding of content and thinking skills, what else guides your selection of instructional approaches?	The availability of resources including time and the number of the learners in my class	The need to **cover certain amount of work within a particular time** and the **performance of learners in tests**. That is important because if learners do not perform because you did not finish	The **ability of these learners to cope with the volume of work** we have to do. To me that is the most important thing.	• Availability of teaching resources • Availability of time • The number of learners in classes • Work to be covered • Performance of the learners in standardised tests

		the work then you are in trouble.		• Ability to cope by learners
What impact does the CPD programs have on your instructional design and practice	All these programs speak of ideal situations and we are facing something else here.	They are very good unfortunately some of the strategies are not applicable in our school. **The time allocated is just not enough** for some of the things.	They are very helpful in some areas like making one aware of the sections to be covered, and to be aware of **what is needed for moderations** at the end of the year.	• Programmes do not address current situations • Strategies are not applicable • No enough time • Very helpful in some areas

4.8 Analysis of teachers' interviews

As indicated above the five interviews questions were designed to further test teachers' beliefs and attitudes on five areas of teaching and learning which are: the teacher's instructional strategy; learners' understanding of the subject content; the development of learners' thinking skills; factors influencing teachers' choice of instructional strategy; and the impact of CPD on the teacher's instructional strategy (Wainwright, Flick & Morrell, 2003) Teachers' interviews responses were then compared to their classroom practices to gain clarity on teachers' attitudes and beliefs about inquiry-based teaching and learning.

4.8.1 Teachers' instructional strategies

The first question of the interviews asked teachers to express their views and understanding on the prescription of inquiry-based teaching and learning by the curriculum. Teachers' responses confirmed that they have difficulties in implementing inquiry-based teaching and learning in their classrooms. These difficulties in implementing inquiry-based teaching and learning are a major contributor in teachers not choosing inquiry-based approaches as pedagogical strategies in their classrooms.

The unavailability of resources like laboratories, the large number of learners in classrooms, the inadequacy of the time allocated in the curriculum, the amount of work to be completed in the curriculum, the lack of inquiry skills by learners, and poor motivation of learners were mentioned as the reasons for the difficulties in implementing inquiry-based teaching and learning. Teachers did not see an inquiry-based approach as applicable, this is captured in Mr Malinga's response:

'I think the people who drafted this policy do not understand what is happening on the ground.'

The curriculum, the conditions at schools and the capabilities of the learners all discouraged teachers from choosing inquiry-based approach. The prescription of inquiry-based teaching and learning in the curriculum did not make teachers choose IBL as a teaching strategy. Teachers' responses to interviews questions were consistent with the observed teachers' practices during lessons. The averages of the RTOP scores for the two observed lessons for each of the teachers were, 24,5 for Mr Malinga (Table 4.14), 21,5 for Mr Mashabane (Table 4.17) and 22,5 for Ms Hlophe (Table 4.20). These RTOP scores points that the observed lessons were straight lectures and heavily teacher centred. Even though the Physical Sciences curriculum promotes the use of inquiry-based strategy, the observed and interviewed teachers still do not prioritise the use of inquiry-based approaches in their classrooms.

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4.8.2 Learners' understanding of the subject content

The second question of the interviews asked teachers to indicate the link between their chosen teaching strategy and learners' understanding of the subject content. Teachers mentioned the lack of resources like textbooks, the lack of skills by the learners, and the need for the learners to do well in standardised tests and examinations as the main reasons in their choice of instructional strategy. Teachers saw themselves as the only source of information, and therefore opted to give learners notes. Learners were reduced to recipients of information which the teachers expected their learners to swallow and reproduce as presented when required. This approach was well represented by part of Ms Hlophe's response:

'these learners do not have the required skills. I end up doing everything myself. '

Focus was not on learners understanding the subject content, but on them swallowing the given information and doing well in standardised tests and examinations. The activities given to the learners as exercises further confirmed these beliefs. This again pointed to the teacher centred approach as observed during lessons.

4.8.3 Development of learners' thinking skills

The third question of the interviews asked teachers to link their chosen instructional approach and the development of learners thinking skills. Teachers' views were that giving learners notes during lessons helps to develop their thinking. The notes were seen as a replacement for the unavailable resources like textbooks. Teachers resumed the role of giving all the information to the learners. The learners' role was reduced to that of recipients of information and writing notes. This was compounded by the fact that teachers viewed the learners as struggling and therefore could not do anything else without being fed. The teachers viewed the lecture method were information is given to the learners as the best teaching approach compared to inquiry-based approaches.

4.8.4 Factors influencing the choice of instructional strategy

The fourth question of the interviews asked teachers to indicate other factors that influenced their choice of instructional strategy. Teachers' indicated that their choice of instructional strategy was mainly influenced by the shortage of resources like textbooks, the performance of learners in the standardised tests and examination, and the need to complete the scheduled work within the allocated time. The teachers' views were that apart from the scarce resources needed for successful inquiry-based lessons, inquiry-based approaches require a lot of time which was not available due to the amount of work to be completed. Due to these difficulties teachers do not choose inquiry-based approach as their instructional strategy.

4.8.5 The impact of CPD on teachers' instructional strategies

The fifth question of the interviews asked teachers to indicate the impact of CPD on their choice of instructional strategy. Teachers felt that CPD programmes were designed with ideal situations in mind, but whatever is presented is not applicable in their schools. While the information provided in the training is good, it is not useful to the teachers in their classrooms. Irrespective of CPD programmes teachers continue to choose instructional strategies based on existing environment within their schools and in their classrooms.

4.9 CONCLUSION

In an effort to triangulate the results of this study, four data collection methods were used and analysed; these were a questionnaire, classroom observations, documents analysis, and interviews. All efforts were made to use standardised data collection instruments, and standardised assessment instruments. In the next chapter, the results of the four data collection methods are then compared with each other and compared with other similar results from other known studies.

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CHAPTER 5: FINDINGS, DISCUSSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of this study was to investigate the beliefs and attitudes of Grade 10 Physical Sciences teachers about inquiry-based teaching and learning. The focus group was Grade 10 Physical Sciences teachers within the Badplaas and Mashishila circuits in Mpumalanga Province. The study was mainly motivated by the fact that the recently introduced South African Physical Sciences CAPS explicitly prescribes scientific inquiry as a strategy to teach and learn effectively Physical Sciences (DBE, 2011). This is a new trend in the Curriculum Statement where a pedagogical strategy is prescribed.

While the researcher was doing the literature review for this study, it was evident that studies investigating teachers' beliefs and attitudes are few and mainly done internationally. No evidence of a similar study done in South Africa within the South African context could be found from the literature consulted. What made the study unique was the fact that all the participating schools were rural schools, and the prevailing conditions are very different from the documented conditions of schools in which teachers' beliefs and attitudes were investigated.

The study was conducted to answer three main research questions:

- What are Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning?
- To what extent is inquiry being implemented in their classrooms?
- What is the relationship between these teachers' beliefs and attitudes about inquiry and their classroom practices?

A sequential explanatory mixed method design was used for the study (Creswell, 2003), where quantitative and qualitative data were collected sequentially, and then merged to better understand the teachers' beliefs and attitudes towards inquiry-based teaching and learning within their world of work. First, quantitative data were collected through a questionnaire, which was developed during the European Union funded project entitled "Promoting Inquiry-Based Learning in Mathematics and Science Education" (PRIMAS), to test teachers on four constructs: teachers' attitudes about inquiry as a pedagogy, teachers' beliefs and readiness to use inquiry as a pedagogy, teachers' current practices and the extent to which teachers employ inquiry in their teaching practices, and the extent to which teachers engage learners in inquiry-based learning activities (PRIMAS, 2011). The questionnaire was distributed to all the 18 secondary schools which have Grade 10 Physical Sciences classes within the two circuits. Eleven teachers responded positively by completing the questionnaire. This was followed by collection of qualitative data from three teachers selected from those who responded positively by completing the questionnaire. Qualitative data were collected by doing classroom observations, interviewing the three selected teachers, and analysis of documents which included lesson plans of the observed lessons presented by the three selected teachers and their learners' worksheets, class work exercises and class tests.

5.2 RESEARCH FINDINGS

In this section the results of the data analysis done in Chapter 4 above were compared and contrasted to provide findings on the three research questions. Aspects of the analysed data from different data sources, were compared with each other and with results of similar studies where such information was available. Themes generated by comparing information from the different data sources, were used to generate findings based on the three research questions. The diagram below shows the different data collection methods used in this study and how they were used in an attempt to answer the three research questions.

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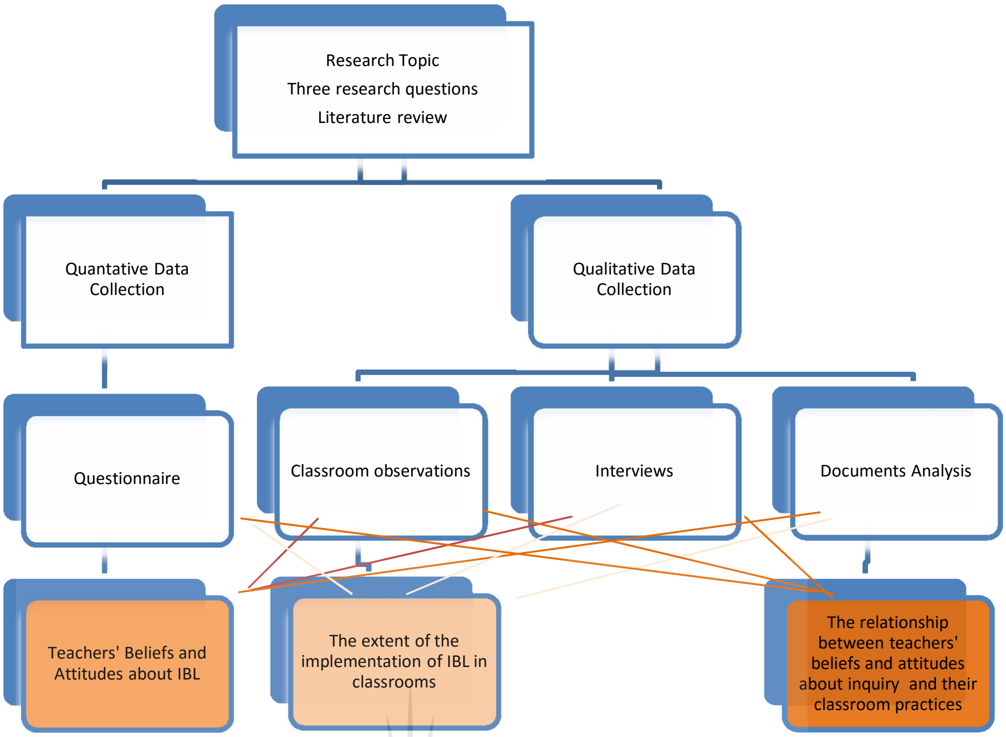

Figure 5.1: Data collection methods

The findings of this study are therefore presented in two sections which are: teachers' beliefs and attitudes about IBL, and implementation of inquiry in science classrooms, as guided by the research questions. The relationship between teachers' beliefs and attitudes about inquiry-based teaching and learning and their classroom practices is presented as part of discussion within the two sections.

5.2.1 Teachers' beliefs and attitudes about IBL

All the four forms of data collections the questionnaire, classroom observations, the interviews and the documents analysis were used to gain an understanding on teachers' beliefs and attitudes about IBL. On a scale of 1 to 4 where 1 represented strongly disagree and 4 represented strongly agree, the average score for the teachers' responses on the eight positive statements about IBL was 3.15 (Table 4.2). An average of 3.15 indicates that teachers agree with the positive statements about IBL. This meant that teachers indicated that they would like to implement more IBL in their lessons, they also view IBL as important for their current teaching practice. Teachers also view IBL as well suited to overcome problems with learners' motivation and to approach learners' learning problems. A positive view also meant that teachers were already using IBL a great deal, and that teachers were open to have more support to integrate IBL in their lessons.

The teachers' average score on the negative statements about IBL was 2. This meant that teachers' disagree with the negative statements about IBL. Teachers did not agree that they see no need to use IBL approaches, that IBL is not effective with lower-achieving learners, and that successful IBL requires learners to have extensive content knowledge. Teachers displayed a positive attitude and beliefs about IBL. The performance of the teachers in the questionnaire is consistent with the findings of the PRIMAS study which investigated teachers' beliefs and attitudes about IBL in a number of European countries. The PRIMAS study found that teachers showed an overall positive orientation towards IBL (PRIMAS, 2011). Saad and BouJaoude (2012) in a study conducted in Lebanon also found that teachers reported a positive attitude and favourable beliefs towards scientific inquiry. A similar outcome was found by Abd-El- Khalick et al. (2004) in a study conducted in a number of European countries, where teachers displayed a positive attitude towards inquiry-based teaching and learning

. The averages of the RTOP scores for the two observed lessons for each of the teachers was far below 50 out of a possible total score of 100: 24,5 for Mr Malinga (Table 4.14), 21,5 for Mr Mashabane (Table 4.17), and 22,5 for Ms Hlophe (Table 4.20). All the observed six lessons were therefore found to be straight lectures which were highly teacher centred. There was no evidence of the teachers using IBL in all the lessons. This contradicted the positive attitude and beliefs teachers displayed in the questionnaire. This is again consistent with the findings of the PRIMAS study which found that while teachers show an overall positive orientation towards IBL, but there was significant differences in the actual routine use of IBL methods in classrooms (PRIMAS, 2011). While teachers acknowledges the value of inquiry-based teaching and learning, teachers find it difficult to move out of their comfort zone, attempt new practices, and challenge some of their personal values and beliefs (Anderson, 2007).

On interviews teachers cited difficulties in implementing inquiry-based approaches in their classrooms. Teachers cited the curriculum, the learners and the conditions in their classroom as reasons for not implementing inquiry-based teaching and learning.

Teachers' views during the interviews were completely different to the views expressed in the questionnaire (Table 4.21). While the questionnaire showed that teachers had a positive attitude and beliefs about inquiry-based teaching and learning, during interviews teachers spoke strongly against the use of inquiry-based teaching and learning. Teachers went up to the extent of questioning the prescription of inquiry-based approaches in the curriculum. Teachers viewed the use of inquiry-based teaching and learning as requiring time, which teachers indicated is not available. Learners were seen as not capable of successfully learning through inquiry-based teaching and learning. Teachers cited learners as lacking necessary skills to learn effectively through inquiry-based approaches. Inquiry was viewed as a teaching and learning strategy suitable for highly gifted and skilled learners. Teachers viewed the conditions in their schools as not supporting the use of inquiry-based teaching and learning. There was mention of overcrowded classrooms and lack of teaching and learning support resources like well-equipped laboratories. Teachers' views during interviews justified the use of teacher-centred teaching and learning approaches during the observed lessons, but contradicted sharply with views expressed in the questionnaire. Teachers' choices of teacher-centred teaching and learning approaches, and their disregard of the prescription of the curriculum was further exposed during the analysis of lesson plans and learners' workbooks. The lesson plans showed no intentions on the part of teachers to use inquiry-based approaches. Teachers never incorporated inquiry-based approaches in their lesson plans. Lesson plans were such that teachers will present all the needed information to the learners, and learners were reduced to recipients of information. Even the planned activities in the lesson plans and those found in the learners' workbooks, were low order recall exercises.

There is therefore no consistency in the data collected using the questionnaire and the data collected through interviews as well as data collected by analysing documents. This might be because the questionnaire was completed by teachers in the absence of the researcher and teachers answered the questionnaire knowing the prescriptions of the curriculum. There is a possibility that teachers wanted to present a picture of themselves conforming to the requirements of the curriculum, which in many instances did not reflect what was truly prevailing in their classes. The interviews on the other hand were conducted after the researcher had observed the teachers' lessons

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presentations. There is therefore a great possibility that teachers' interview responses were a true reflection of what is prevailing in their classrooms. Teachers' responses during interviews were further supported by the data generated by the analysis of documents. The data collected through interviews and that generated by the analysis of documents points to the fact that teachers prefer to use the traditional teacher-centred approaches as compared to the promoted inquiry-based approaches.

Teachers are aware of the requirements of the curriculum, and are aware that it is expected of them to use inquiry-based approaches in their lessons. Teachers' awareness of inquiry-based approaches are shown by their positive responses in the questionnaire. However teachers' responses during the interviews and the analysis of documents showed that the difficulties in implementing inquiry-based teaching and learning, dictates for the use of the traditional teacher-centred approaches.

5.2.2 Implementation of inquiry in science classrooms

Three sources of data, the questionnaire, classroom observations and analysis of documents were used to determine the level of the implementation of inquiry in science classrooms.

As indicated in Table 4.8, items assessing teachers' and learners' activities during lessons on implementation of IBL in classroom were grouped into six subscales. These subscales were: EXE which reports on whether the lessons are more teacher centred or more learner-centred, APP which reports on the frequency of teaching with a focus on application and on relationship to daily life, INT which measures the frequency of learners' interaction focusing on discussion, EDI which measures the frequency of discussion regarding experiments, HON which measures the frequency of practical activities with a focus on the hands-on aspect, and INV which captures the frequency of investigation (PRIMAS, 2011).

The average of 2.4 on EXE indicated a low frequency of inquiry- based exercises during lessons. The same results were found during classroom observations where the RTOP scores for all the observed lessons had a score far less than 50, indicating that the lessons were straight lectures. The same pattern of less inquiry-based exercises in the classrooms was revealed by the analysis of lesson plans. Analysis of lessons plans revealed no evidence of explicit planning for inquiry-based exercises and no evidence as such could be found in learners' workbooks. It was finally confirmed by the teachers in interviews where a number of reasons were cited for not implementing inquiry-based teaching and learning. Lessons were found to be more teacher centred and learners were deprived of opportunities to engage in inquiry-based exercises.

This confirms what was suggested by Anderson (2002) that positive attitudes and favourable beliefs about inquiry-based teaching and learning do not translate to implementation of inquiry in classrooms. Abd-El- Khalick et al. (2004) in their study in a number of European countries also found that teachers' attitudes and beliefs conflicted with what was prevailing in classrooms.

The average of 3.2 on APP indicated a high frequency of focus on applications to real life situations. This contradicted the findings of the classroom observations. There was no application of learnt concepts to real life situations in all the observed lessons. While in the questionnaire teachers indicated this aspect of inquiry-based teaching and learning as important, there was no attempt by the teachers to include this during the observed lessons presentations. This was also confirmed during interviews where teachers cited the large numbers of learners in classes, the pressure to complete given schedules within a particular time and inability of their learners to engage in inquiry activities as factors inhibiting exploration outside the prescribed subject content.

The average on INT is 3.1 which indicates that most teachers regard learners' interaction as a prevalent element of their lessons. This again was contradicted by the classroom observations. Classroom observations showed classes to be straight lectures and more teacher centred, and there was no evidence of learners' interaction with the teacher or with each other. Learners were just passive recipients of information in all the observed lessons.

The average for EDI is 2.8 which indicates that there are discussions of experiments in some of the lessons. Again this was contradicted by the findings of classroom observation and document analysis. While teachers have high regard for experiments, practically they were not conducted in classrooms. Teachers appreciate the value experiments can bring in their classes; however, they all reported varying reasons why conducting experiments is not possible in most cases. This included big numbers in

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classes, unavailability of resources, and allocation of time in the curriculum to conduct experiments against completion of the schedules.

The average for HON is 2.7 which indicates that hands-on experiments can be found in some lessons, and average for INV is 2.5 which also indicates that investigations can be found in some lessons. However as indicated above no evidence of such was found in classroom observations or in the document analysis. The lesson plans showed no intention on the part of the teachers to engage learners in hands-on experiments or investigations. This was further confirmed by teachers' responses during interviews where hands-on experiments and investigations were viewed as competing with the time to finish the schedule and preparing learners for standardised tests and examinations.

While the teachers' responses to the questionnaire portrayed teachers as having positive attitudes and beliefs about inquiry-based teaching and learning, the lesson observations, teacher interviews, and the analysis of artefacts showed no evidence of the teachers employing inquiry-based teaching and learning as a preferred pedagogical strategy. While attitudes and beliefs are seen as best indicators of the decisions teachers take when planning lessons and when delivering the lesson (Saad & BouJaoude, 2012), this study could not find any correlation between teachers' attitudes and beliefs and teachers' choices of instructional strategy and classroom practices. This confirms that teachers' attitudes and beliefs cannot be the sole factor in teachers' decisions and choices of instructional strategies (Saad & BouJaoude, 2012). Implementation of inquiry-based teaching and learning does not only need teachers who believe in inquiry-based teaching and learning, but also teachers who are well prepared and confident in their abilities to teach using inquiry-based approaches (Harwood, Hansen & Lotter, 2006).

Teachers further mentioned a number of factors as reasons for the difficulties in implementing inquiry-based teaching and learning.

5.2.3 Difficulties in implementing inquiry in science classrooms

The questionnaire also assessed teachers on the difficulties teachers are experiencing in the implementation of inquiry-based strategies as reported in Section 4.3.3.2. Teachers were also asked to comment in an open question on difficulties in implementing inquiry-based strategies, and finally teachers expressed themselves on the difficulties during interviews.

The following were difficulties in implementing IBL as mentioned by the teachers interviewed.

5.2.3.1 Teaching materials

Nine teachers agreed that lack of adequate teaching materials is a reason for the difficulty in implementing inquiry-based teaching and learning. During interviews teachers emphasised the difficulty in implementing inquiry-based teaching and learning without adequate equipment. Lack of adequate teaching materials negatively affects the implementation of inquiry-based teaching and learning, because inquiry-based teaching and learning is effective if teachers and learners can use a multi-text approach (Llewellyn, 2005; Bell, Maeng & Peters, 2013).

However, the observations of lessons revealed that even in schools where equipment were available, teachers made no effort to use them to teach in an inquiry-based way. Within the two circuits there are also six schools identified as MST schools. These schools were supplied with all the materials and equipment to teach mathematics, sciences and technology effectively. All the six teachers from these schools participated in the study and completed the questionnaire. Two of the teachers whose lessons were observed came from two of the MST schools. However the unavailability of adequate teaching material was mentioned as the main difficulty.

5.2.3.2 Learners' ability

The second frequently mentioned difficulty was a concern by teachers about their learners getting lost and frustrated in their learning. Teachers were overwhelmed by the concern that learners cannot cope with inquiry-based approaches. And therefore to the teachers the ability of the learners was one of the main difficulties in the implementation of inquiry-based strategies. This can be viewed that teachers had an inherent belief that inquiry- based approaches can only work for a particular type of learners.

5.2.3.3 Large number of learners in classes

The number of learners in classes was also identified as the difficulty in the implementation of inquiry-based strategies. The teachers also confirmed this during interviews as indicated in 5.2.3.2 above. The number of learners in classes was also a determining factor in teachers choosing how to teach the class.

5.2.3.4 Not enough time in the curriculum

The most mentioned difficulty during interviews was the unavailability of time for teachers to teach using inquiry-based approaches and be able to cover the set amount of work within a specified time. The pressure to complete the schedule as prescribed discourages teachers in engaging learners in inquiry-based approaches which are then seen as time wasting.

5.2.3.5 Insufficient resources such as computers and laboratory

To a lesser extent teachers also identified insufficient resources such as computers and laboratories as the difficulty in implementing inquiry-based approaches. As mentioned above, this could not be the reason for six of the schools within the two circuits. Surprisingly the lessons observed did not require sophisticated equipment and resources for an inquiry-based approach to be effective.

It is the view of this study that some of the difficulties raised could not have prevented the teachers from employing inquiry-based strategies to a certain extent. There are aspects of inquiry-based approaches that do not need the availability of resources or equipment.

5.3 RECOMMENDATIONS

This study makes the following recommendations.

Because of the small sample used in this study, it is recommended that a long-term study with a larger-sample be conducted. A long term study with a larger sample will give authoritative findings on teachers' attitudes and beliefs towards inquiry-based teaching and learning. Such a study would also give detailed answers on why teachers who have positive attitudes and favourable beliefs towards inquiry would continue to favour the traditional way of teaching in their classes. Empirical evidence needs to be collected on factors affecting South African teachers' choices of pedagogical strategy. Authoritative findings on factors influencing South African teachers' decision making and choices of pedagogical strategies will assist in developing effective teacher development programmes.

Although this study did not assess the effectiveness of the Teacher Development Programmes and workshops, serious questions are raised by the responses and practices of teachers. It is the recommendation of this study that research needs to be conducted to assess the effectiveness of the training that teachers receive, especially training that focuses on curriculum delivery. The findings of this study are that teachers continue to teach learners using the traditional lecture method of teaching while the curriculum expects teachers to incorporate scientific inquiry into the science classrooms. In the questionnaire teachers conceded that they would like to have more opportunities to undertake CPD. Teachers also indicated a need for more support to integrate inquiry-based teaching and learning into their lessons. In the study by Abd-El- Khalick et al. (2004) teachers indicated similar concerns, that intensive professional development activities reduces their anxiety and increased their confidence to use learner-centred teaching approaches. It is therefore a recommendation of this study that an intensive programme to train teachers and equip them with skills to integrate inquiry-based approaches in their lessons should be developed. Anderson (2007) strongly advocates that teachers have to be the focal point of a move towards more inquiry-oriented science education. There can be no effective implementation of inquiry-based teaching and learning in science classrooms without proper development of teachers.

Apart from professional teacher development, quality inquiry science materials are of major importance and influence in classrooms (Anderson, 2007). It is the recommendation of this study that to improve the possibility of effective implementation of inquiry-based teaching and learning in science classrooms, there should be development of quality materials that meets the following four distinguishing characteristics:

- Are standards-based in that the science content, instructional strategies, and assessment tools optimize learning as reflected in current research on teaching and learning.

- Are inquiry-based, which includes support for inquiry as a teaching strategy as well as the inclusion of content that addresses the abilities to do inquiry and the understandings about science as inquiry.
- Are based on a carefully developed conceptual framework that reflects the science disciplines and connects factual information to larger ideas, themes, and concepts.
- Are revised as a result of thoughtful and comprehensive field testing, which provides developers with data about the effectiveness of the materials used by teachers and learners (Anderson, 2007).

There is a need in investment in developing quality inquiry-based materials that's support teachers and provide learners with more robust opportunities to engage in science practices that are not typically implemented in science classrooms (Harris, Penuel, DeBarger, D'Angelo, & Gallagher, 2014).

5.4 LIMITATIONS AND DELIMITATIONS

Limitations are those factors that are beyond the control of the researcher, but if they disappeared would make the study irrelevant (Simon, 2011). Limitations are therefore weaknesses that may affect the results of the study (Baron, 2008). This study has the following limitations:

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1. All the participants were volunteers who could withdraw at any point in the study. The researcher could not manage the schedule for the completion of the study due to the fact that some participants exercised their right to withdraw in the middle of the study. This also compromised the representativeness of the views and practices captured in this study.
2. The study focused on two education circuits which are both in rural areas. The population of the study does not represent the diversity within South Africa, and therefore the findings of this study cannot be generalised to cater for all the teachers in South Africa.
3. Due to the smaller sample of the participants, the results of the study could not be generalised with confidence to the larger population.

Delimitations are those characteristics that limit the scope and define the boundaries of the study by establishing parameters (Baron, 2008; Simon, 2011). The researcher has control over delimitations. The following delimitations influenced this study:

1. This study focused on Grade 10 Physical Sciences within only two circuits within the Gert Sibande District in Mpumalanga province.
2. This study chose to focus on teachers' beliefs and attitudes towards inquiry-based teaching and learning. It should be noted that this is just one of many factors that affect teachers' choices of pedagogical strategies and their classroom practices.
3. This study did not interrogate teachers' training and level of qualifications. Teachers' level of training and qualifications will determine teachers' Pedagogical Content Knowledge, which plays a major role in teachers' choices of pedagogical strategies and their classroom practices.

5.5 CONCLUSION

It is worth emphasising that the study included just 11 out of 18 schools within two circuits in the Gert Sibande District in Mpumalanga province. The results of this study could not be generalised with authority because of the small sample used in the study. The study intended to contribute to the body of knowledge about the actual practices of teachers and reasons for teachers' choices of pedagogical instructions. This study should therefore be used as a base for a bigger and broader study to evaluate and document South African teachers' classroom practices and factors influencing such practices. This is even more important and relevant in view of the lack of such studies, documenting teachers' attitudes, beliefs and classroom practices in rural schools of South Africa.

This study has found that while teachers attended capacity-building workshops in preparation for the introduction of the new curriculum which prescribes the use of scientific inquiry in the teaching of Physical Sciences (DBE, 2011), there was no evidence of the implementation of inquiry-based approaches in the rural schools studied. While teachers expressed positive attitudes and favourable beliefs towards inquiry-based approaches, they still could not choose inquiry-based strategy in planning for their lessons. Teachers were not confident enough that inquiry-based

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approaches can be the answer to the challenges they are facing in the teaching of Physical Sciences.

This study found no evidence of any traces of inquiry-based teaching and learning strategies in lesson presentations, lesson plans and learners' workbooks. It can therefore be concluded that there was no implementation of inquiry-based approaches in the rural schools studied. Faced with the challenges of overcrowded classrooms, the pressure of completing prescribed work schedules within a specified period, lack of teaching and learning materials and teacher development programmes which do not prepare teachers to face these challenges, teachers see the traditional teacher-centred approach as the perfect solution.

While the teachers reported positive attitudes and favourable beliefs, implementation of inquiry-based approaches could not be found. Therefore it can be concluded that there is no correlation between the Grade 10 Physical Sciences teachers' attitudes and beliefs and their classroom practices.

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APPENDICES

Appendix A: Letter to the Mpumalanga Department of Education requesting permission to conduct research.

Stand No 904

Longhomes

P O Box 926

Elukwatini 1192

18 March 2014

UNIVERSITY
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ATTENTION

Mr Baloyi

Department of Education Mpumalanga Province

Nelspruit

FROM

Mr Hlatshwayo MS (Persal: 80831877)

Educator : Litjelembube Secondary School (Mathematics and Physical Sciences)

Gert Sibande District

Mashishila Circuit

Dear Sir

SUBJECT: REQUEST TO CONDUCT RESEARCH STUDY FOR M.Ed DEGREE

I Hlatshwayo Manzini Samson currently employed by the Department of Education Mpumalanga Province as the principal and a Mathematics and Physical Science educator at Litjelembube Secondary School, I am currently studying towards a Masters Degree in Science Education with the University of Johannesburg. As part of the requirements of the degree, I am to conduct a research study and my research topic is to investigate Grade 10 Physical Sciences teachers' beliefs and attitudes about inquiry-based teaching and learning.

I hereby humble request permission to be allowed to conduct the research study in all the secondary school in the Badplaas circuit (11) and in the Mashishila circuit (10), both circuits are in the Gert Sibande District. The two circuits have been conveniently selected because of their locality relative to my station of employment. Inquiry features prominently in the South African Physical Sciences Curriculum and Assessment Policy Statement (CAPS), which states that the purpose of Physical Sciences as a subject is to "promote knowledge and skills in scientific inquiry" (Department of Basic Education, 2011, p.8).

The study will therefore investigate the Grade 10 Physical Sciences teachers' beliefs and attitude about inquiry-based teaching and learning, and assess the extent to which inquiry is being implemented in the Grade 10 Physical Sciences classrooms within the two circuits. Inquiry-based teaching and learning has been identified as the cornerstone of ongoing science education reforms (Harwood, Hansen & Lotter, 2006; Smolleck & Mongan, 2011; Smolleck, Zembal-Saul & Yoder, 2006; Zion, 2007; Zion, Cohen & Amir, 2007). Inquiry-based teaching and learning cannot therefore be ignored in the journey of improving the teaching of Physical Sciences and the performance of the learners in the subject. Despite growing consensus regarding the value of inquiry-based teaching, the implementation of such a pedagogical practice continues to be a challenge for many teachers (Chan, 2010; Dillon, 2008; Harwood, Hansen & Lotter, 2006; Smolleck & Mongan, 2011; Trautmann, MaKinster & Avery, 2004). It is therefore important that teachers' beliefs and attitudes about inquiry-based teaching and learning, and the extent to which inquiry-based teaching and learning is implemented in classrooms be documented.

The study will be conducted in two phases, the first phase will be a quantitative study were a questionnaire will be distributed to all the Grade 10 Physical Sciences teachers in the secondary schools of the two circuits. The questionnaire will be completed during teachers own time and therefore will not interfere with their core functions. The questionnaire will be analysed and three educators will be chosen on the bases of their responses for the second phase of the study. The second phase of the study will be a qualitative study were the three chosen teachers will be interviewed, their lessons will be observed and video recorded, and learners' workbooks will be analysed to determine the extent to which inquiry-based instructions are employed in teaching and learning. Interviews will be conducted outside the teaching time within the school, and observations of lessons will be such that it does not disrupt teachers' work.

The study will assist in documenting teachers' beliefs and attitudes about inquiry-based teaching and learning as a pedagogical strategy, and the extent to which it is implemented as required by the Curriculum Statement. The data collected will only be used for the study and nothing else. The final report of the study will be made available to all the participating school and the participating teachers.

Find attached my Research Proposal as approved by my supervisor, the ethical clearance given by the University ethics committee.

Hoping that you will find this in order.

Yours faithfully

……………………………… ……………………..

Hlatshwayo MS Date

UNIVERSITY OF JOHANNESBURG

Appendix B: Response letter from the Mpumalanga Department of Education

RESEARCH APPLICATION FOR MR. M.S. HLATSWAYO: REQUEST FOR YOUR APPROVAL. (M.ED DEGREE)

education
DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

Private Bag X 11341
Nelspruit 1200
Government Boulevard
Riverside Park
Building 5
Mpumalanga Province
Republic of South Africa

Litiko leTemfundvo Umnyango weFundo Departement van Onderwys Umnyango wezeMfundo
Enquiries: H.A. Baloyi (013) 766 5476

Mr. M.S. Hlatswayo
P.O. BOX 755
Elukwatini
1192

RE: APPLICATION TO CONDUCT RESEARCH: MR. M.S. HLATSWAYO

Your application to conduct research was received. The title of your study is: "Beliefs and Attitudes of Grade 10 Physical Science Teachers." The aims, objectives, the questions and the overall design of your study give an impression that the outcomes of the study will improve the teaching and learning of Physical Science in the FET level. Your request is approved subject to you observing the content of the departmental research manual which is attached. You are required to discuss with the principals of the sampled schools regarding the approach to your observation and data collection as no disruption of tuition will be allowed. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document.

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In terms of the attached manual (2.2. bullet number 4 & 6) data or any research activity can only be conducted after school hours as per appointment. You are also requested to share your findings with the relevant sections of the department so that we may consider implementing your findings if that will be in the best interest of department.

For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za. The department wishes you well in this important project and pledges to give you the necessary support you may need.

MPUMALANGA
A Pioneering Spirit

Sisonke Sifundzisa Sive

RESEARCH APPLICATION FOR MR. M.S. HLATSWAYO: REQUEST FOR YOUR APPROVAL. (M.ED DEGREE)

APPROVED/NOTAPPROVED:

____

____

____

____

MRS MOC MHLABANE
HEAD OF DEPARTMENT

25, 4, 14
DATE

UNIVERSITY OF JOHANNESBURG

Appendix C: Letter to Circuit Managers requesting permission to conduct research

ENQ: Manzini Samson Hlatshwayo
CELL: 0823025137
Email: manzini6712@gmail.com
Student No: 201280245

P.O. BOX 926
ELUKWATINI
1192

04 June 2014

THE CIRCUIT MANAGER
BADPLASS CIRCUIT
SIPHUMELELE TEACHERS CENTRE
1192

DEAR SIR

RE: REQUEST FOR CONSENT TO CONDUCT RESEARCH WITHIN THE CIRCUIT
I am currently studying with the University of Johannesburg towards a Masters Degree in Sciences Education. As part of my study I hereby request permission to conduct a research within the circuit focusing on the grade 10 Physical Sciences Educators.

The research will involve questionnaires, classroom observations and interviews with the participating educators. Efforts will be made never to disrupt the normal working of the educators. The research is aimed at finding effective teaching strategies, educators will benefit from the interviews in reflecting on their teaching strategies. A copy of the final report will be made available to all the participating schools and educators.

Request for the study have been made and approved by the Mpumalanga Education Department find attached copy.

Attached is the University consent form which must be signed so that I can submit to the University research committee.

UNIVERSITY
OF
JOHANNESBURG

Thanking you in anticipation.
Yours faithfully
Manzini Samson Hlatshwayo

____

Date

____

Appendix D: Letter to Principals requesting permission to conduct research

ENQ: Manzini Samson Hlatshwayo
CELL: 0823025137
Email: manzini6712@gmail.com
Student No: 201280245

P.O. BOX 926
ELUKWATINI
1192

17 June 2014

THE PRINCIPAL
MKOLISHI SECONDARY SCHOOL
DEAR SIR/MADAM

RE: <u>REQUEST FOR CONSENT TO CONDUCT RESEARCH</u>

I am currently studying with the University of Johannesburg towards a Masters Degree in Sciences Education. As part of my study I hereby request permission to conduct a research within the school focusing on the grade 10 Physical Sciences Educator (s).

The first phase of the research is conducted by asking the educator(s) to complete a questionnaire. Only selected educators will be asked for classroom observations and interviews. All efforts to avoid or minimise disruption of the normal working of the educators will be made.

The research is aimed at finding effective teaching strategies, and participating educators will benefit from the interviews by reflecting on their teaching strategies. A copy of the final report will be made available to all the participating schools and educators.

Request for the study have been made and approved by the Mpumalanga Education Department find attached copy.

Attached is the University consent form which must be signed to confirm participation or not participating in the study.

Thanking you in anticipation.
Yours faithfully
Manzini Samson Hlatshwayo

____

Date

____

UNIVERSITY OF JOHANNESBURG

Appendix E: Letter to teachers inviting them to be participants in the research project

ENQ: Manzini Samson Hlatshwayo
CELL: 0823025137
Email: manzini6712@gmail.com
Student No: 201280245

P.O. BOX 926
ELUKWATINI
1192
17 June 2014

DEAR Grade 10 Physical Sciences Educator

RE: INVITATION TO PARTICIPATE IN A STUDY
I humble invite your participation in a study for partial fulfilment of a Masters Degree in Sciences Education with the University of Johannesburg. The study investigates grade 10 Physical Sciences educators' beliefs and attitudes about inquiry teaching and inquiry learning.

Participation in the study is voluntary, participates can withdraw from the study at any time, and the information supplied for the study will be used for the purpose of the study and nothing else. All efforts will be made to keep participants' identity as confidential as possible unless permission is given by the participants. Participants can at all times communicate with the researcher to confirm, modify or add information, and monitor the progress of the study.
The first phase of the research is conducted by asking grade 10 Physical Sciences educator to complete a questionnaire. Only selected educators will be asked for classroom observations and interviews. All efforts to avoid or minimise disruption of the normal working of the educators will be made.

A copy of the final report will be made available to all the participating schools and educators.

Request for the study have been made and approved by the Mpumalanga Education Department find attached copy.

Attached is the University consent form which must be signed to confirm participation or not participating in the study.

Thanking you in anticipation.
Yours faithfully
Manzini Samson Hlatshwayo

Date

UNIVERSITY OF JOHANNESBURG

Appendix F: PRIMAS questionnaire for teachers

Primas

4. Appendices

4.1. Appendix 1: Questionnaire

Primas

PROMOTING INQUIRY IN MATHEMATICS AND SCIENCE EDUCATION ACROSS EUROPE

www.primas-project.eu

Dear teacher,

we would like you to take part in this survey as part of the European project PRIMAS. Please fill out the questionnaire anonymously.

PRIMAS aims to effect a change across Europe in the teaching and learning of mathematics and science by supporting teachers to develop inquiry-based learning (IBL) pedagogies. IBL strategies in the classroom enable students to get a first-hand experience of scientific inquiry, stimulate intrinsic motivation and generate interest for the learning in science and mathematics.

The aim of this survey is to find out about the European situation regarding inquiry based learning and teaching across different countries and disciplines.

Thank you for your help.

Your PRIMAS-Team

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Continuing Professional Development (CPD)

The aim of CPD is to develop teachers' competencies related to their profession. The CPD events last at least half a day, but there are also long term trainings with for example several meetings within a period of two years.

In the following section we would like to know about your attitude towards CPD.

8. How many days did you participate in professional development events over the past years? Please fill in the numbers.

0-2 years ago	3-4 years ago	5-6 years ago	7-8 years ago

9. .

	mainly no	half and half	mainly yes
I participated in CPD because it was compulsory.			

10. To what extent do you agree with the following statements concerning CPD.

	strongly disagree	disagree	Agree	strongly agree
a. Engaging in CPD can help me to become a better teacher.				
b. Through CPD I can attain greater professional satisfaction.				
c. I would like more opportunities to undertake CPD.				
d. CPD is only necessary for those new to the profession				
e. CPD is only important for those seeking greater responsibility.				
f. It is difficult for me to see the value of CPD.				
g. CPD is necessary to update my repertoire of teaching methods.				
h. The provision of CPD opportunities can increase staff morale.				
i. CPD is necessary in order to update subject knowledge.				
j. Engaging in CPD can make me more confident in performing my role.				
k. CPD is necessary to update pedagogical skills.				
l. Teachers with a great deal of professional experience don't need CPD.				

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The project PRIMAS has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 244380.

Inquiry Based Learning (IBL)

Inquiry based learning (IBL) is a student-centred way of learning content, strategies and self-directed learning skills. Students

- develop their questions to examine,
- engage in self-directed inquiry (diagnosing problems - formulating hypothesis - identifying variables - collecting data – documenting their work - interpreting and communicating results)
- collaborate.

The aim of IBL is to stimulate students to adopt a critical inquiring mind and problem solving aptitudes.

11. Please indicate to what extent you agree with the following statements.

	strongly disagree	disagree	agree	strongly agree
a. I would like to implement more IBL practices in my lessons.				
b. IBL is important for my current teaching practice.				
c. Successful IBL requires students to have extensive content knowledge.				
d. IBL is not effective with lower-achieving students.				
e. I see no need to use IBL approaches.				
f. IBL is well suited to overcome problems with students' motivation.				
g. IBL provides material for fun activities.				
h. I already use IBL a great deal.				
i. I would like to have more support to integrate IBL in my lessons.				
j. IBL is well suited to approach students learning problems.				
k. I regularly do projects with my students using IBL.				

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12. Please indicate to what extent you agree with the following statements.

I have difficulties in implementing IBL, because…	strongly disagree	disagree	agree	strongly agree
a. the curriculum does not encourage IBL.				
b. I don't have enough time to prepare IBL lessons.				
c. I don't have adequate teaching materials.				
d. IBL is not included in textbooks I use.				
e. I don't know how to assess IBL.				
f. I don't have access to any adequate CPD programs involving IBL.				
g. I worry about students' discipline being more difficult in IBL lessons.				
h. I don't fell confident with IBL.				
i. I worry about my students getting lost and frustrated in their learning.				
j. my colleagues do not support IBL.				
k. I think that group work is difficult to manage.				
l. there is not enough time in the curriculum.				
m. I don't have sufficient resources such as computers, laboratory,…				
n. my students have to take assessments that don't reward IBL.				
o. the number of students in my classes is too big for IBL to be effective.				

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13. Please comment on the main difficulties that hinder the implementation of IBL in your lessons.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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Description of your current practice

Now we would like you to think of a certain group you teach.

14. Subject

Maths	Physics	Biology	Chemistry	Combined, balanced or general Science

15. Age Group

a.	Year 3 and below	(8 years and younger)	
b.	Years 4 & 5	(8 to 10 years)	
c.	Years 6 & 7	(10 to 12 years)	
d.	Years 8 & 9	(12 to 14 years)	
e.	Years 10 & 11	(14 to16 years)	
f.	Years 12 & 13	(16 years and older)	

16. When teaching this subject to this class, how often do the following activities occur in your lessons?

In my lessons…	never or hardly ever	in some lessons	in most lessons	in almost all lessons
a. I have my students working on their own, consulting a classmate from time to time.				
b. I encourage my students to use only the methods I teach them.				
c. I give my students the opportunity to choose which questions they tackle.				
d. I encourage students to work more slowly.				
e. I teach the whole class at once.				
f. I draw links between topics and move back and forth between topics.				
g. I am surprised by the ideas that come up in a lesson.				
h. I avoid students making mistakes by explaining things carefully first.				
i. I tend to follow the textbooks or worksheets closely.				
j. I try to teach each learner differently according to individual needs.				
k. I try to cover everything in a topic.				
l. I try to remove students fear about failure.				
m. I explain how a school math/science idea can be applied to a number of different phenomena.				
n. I use the math/science to help students understand the world outside school.				

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In my lessons…	never or hardly ever	in some lessons	in most lessons	in almost all lessons
o. I clearly explain the relevance of math/science concepts to daily life.				
p. I enable students to make presentations.				
q. I circulate and interact with students.				
r. I discuss variations in data collected by students following their experiments.				
s. I use questioning strategies to respond to students' questions.				
t. I have students ask questions about math/scientific phenomena addressed during experiments.				
u. I have students engage in discussions among themselves.				

17. When teaching this subject to this class, how often do your students do the following activities during your lesson?

In my lessons my students…	never or hardly ever	in some lessons	in most lessons	in almost all lessons
a. learn through doing exercises.				
b. start with easy questions and work up to harder questions.				
c. work collaboratively in pairs or small groups.				
d. are given opportunities to explain their own ideas.				
e. have discussions about the topics.				
f. do practical activities.				
g. draw conclusions from an experiment they have conducted.				
h. do experiments by following my instructions.				
i. are allowed to design their own experiments.				
j. are asked to do an investigation to test out their own ideas.				
k. have opportunities to work with little or no guidance.				

Thank you !!!

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Appendix G: RTOP lesson observation tool

RTOP: Reformed Teaching Observation Protocol

Teacher Candidate: ____________________

Observer: ____________________

Grade Level: __________ Date of Observation: __________

Lesson Plan & Implementation

	Never Occurred				Very Descriptive
1.) Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0	1	2	3	4
2.) The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3.) In this lesson, student exploration preceded formal presentation.	0	1	2	3	4
4.) This lesson encouraged students to seek and value alternative modes of investigation or of problem solving	0	1	2	3	4
5.) The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

Content

		Never Occurred				Very Descriptive
Propositional	6.) The lesson involved fundamental concepts of the subject.	0	1	2	3	4
	7.) The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4
	8.) The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4

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	9.) Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.		0 1 2 3 4
	10.) Connections with other content disciplines and/ or real world phenomena were explored and valued.		0 1 2 3 4
Procedural Knowledge	11.) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.		0 1 2 3 4
	12.) Students made predictions, estimations and/or hypotheses and devised means for testing them.		0 1 2 3 4
	13.) Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.		0 1 2 3 4
	14.) Students were reflective about their learning.		0 1 2 3 4
	15.) Intellectual rigor, constructive criticism, and the challenging of ideas were valued.		0 1 2 3 4

Classroom Culture

			Never Occurred				Very Descriptive
Communicative Indicators	16.) Students were involved in the communication of their ideas to others using a variety of means and media.		0	1	2	3	4
	17.) The teacher's questions triggered divergent modes of thinking.		0	1	2	3	4
	18.) There was a high proportion of student talk and a significant amount of it occurred between and among students.		0	1	2	3	4
	19.) Student questions and comments often						

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	determined the focus and direction of classroom discourse.		0 1 2 3 4
	20.) There was a climate of respect for what others had to say.		0 1 2 3 4
Student/ Teacher Relationships	21.) Active participation of students was encouraged and valued.		0 1 2 3 4
	22.) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.		0 1 2 3 4
	23.) In general the teacher was patient with students.		0 1 2 3 4
	24. The teacher acted as a resource person, working to support and enhance student investigations.		0 1 2 3 4
	25.) The metaphor "teacher as listener" was very characteristic of this classroom.		0 1 2 3 4

Feedback

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Appendix H: Transcribed lessons

TRANSCRIPT

LESSON OBSERVATION

MR MALINGA'S LESSON 1

SUBJECT: Physical Sciences

GRADE : 10

TOPIC: EQUATIONS OF MOTION

Teacher : Afternoon class. Today we have a visitor from Litjelembube Secondary School Mr Hlatshwayo who is also a science teacher, and we will be learning together. I would like you to participate, make sure you co-operate.

Teacher : Our lesson for today is equations of motion, equations of motion, equations of motion. It has become very important for us to learn about equations of motion to solve the problems we have concerning equations of motion. We need the equations to be able to solve problems concerning equations of motion. Without wasting time I will give you the equations of motion that we are going to use.

The first one is $v_f = v_i + a\Delta t$

The second one is $v_f^2 = v_i^2 + 2a\Delta x$

The third one is $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

The fourth one is $\Delta x = \left(\frac{v_f + v_i}{2} \right) \Delta t$

So let me wait for you so that you can write this down.

Is everyone finish. Ok without wasting time let me ask you what does v_f stand for?

Learner : Final velocity

Teacher : Final velocity, what about v_i ?

Learner : Initial velocity

Teacher : Initial velocity. So what about this small letter a?

Learner : Tried but very soft.

Teacher : Raise your voice

Learner : Acceleration

Teacher : Acceleration. All of you.

Class : Acceleration (loud)

Teacher : Acceleration. What about this one delta t (Δt)

Leaner : Time

Teacher : Time. Anything left?

Class : Yes (loud)

Teacher : What is it?

Class : Delta x (Δx)

Teacher : Delta x, what is this delta x, (Jabu)

Learner : Speed

Teacher : Speed, you agree?

Class : No

Teacher : Ok, Thathu

Leaner : Distance

Teacher : Distance

Class : No (loud)

Teacher : Uh, yes Sibahle

Learner : Displacement

Class : Yes

Teacher : It could also be distance, but we are going to use displacement. Lets come to the units. Units are very important. You can't just put the size without any meaning. Size has got no meaning. So we need to make sure we make use of units so that we are sure of what we are trying talking about. So velocity, final velocity what are the units of final velocity?

Learner : metres per second (m/s)

Teacher : Initial velocity, initial velocity, units of initial velocity……………………..what are the units of initial velocity? Ayanda.

Learner : metres per second (m/s)

Teacher : Still metres per second (m/s)

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Teacher : and what about acceleration………………….acceleration?

Learner : metres per second squared (m/s ^{2})

Teacher : metres per second squared (m/s ^{2}), what about time, Lindo

Learner : Second

Teacher : Seconds, all of you.

Class : seconds

Teacher : seconds then what about displacement……………………………. What about displacement?

Leaner : metres

Teacher : Make sure each time you are trying to calculate each and every one of the variables using each one of the equations of motion her, make sure that at the end you make sure you write the correct units. It very much important to practice this units so that you know exactly what you are trying to calculate. Right. Without wasting time let's come to this one, how can you make use of the equations of motion easily without encountering problems. There are certain steps that you need to follow so that you make your calculation or any problem you come across easily to solve, or easy to deal with. Who can just tell us. Its not for the first time that you are using the equation. Is n't it? So if you come across or you make use of any like any other equation you have used before by the way what is the first thing you need to do if you are given let us say a certain exercise to solve or a problem to solve? What is the first thing you need to do?

Learner : You write down all the given values.

Teacher : It means you have to write down the quantities. Close the textbooks. I want to be sure you know exactly what to do. Please close everything. Close your textbooks. I will tell you to make use of them. So first of all you have to write down all the given values and even including those that you are trying to calculate, including the one you are trying to calculate. What is the second? What is the second one?

Learner : Choose which equation to use.

Teacher : It means if you have listed the variables that you are given and you have also listed, including the one you are trying to calculate. It means its easy now for you to identify the correct formula because you have got the right data, you can be able to identify the correct formula (writes on the board identify the formula). Thirdly what is important?

Learner : Substitute the given values.

Teacher : Yes, you have to substitute the given values. The last one?

Learner : Calculate the unknown quantity.

Teacher : If you have substituted the correct variable you are left with the unknown variable, the variable you are trying to calculate. Is n't it? Now, so let me give you this example, this first example. Just write it down.

An air craft accelerates from rest at $8m/s^2$ down a run way. Calculate how fast it will be travelling

after 40s.

Teacher : Now write down the data, follow the steps given on the board and see if you cannot be able to come out with the right formula. Follow the steps written on the board and see if you cannot come up with the correct formula. I want to see your data. I will be moving around. I want to ensure that you have written your data and you also have indicated the one you are trying to calculate. Please start by writing the correct data. Don't simple choose the formula. Start by writing the correct data. Make sure you follow our rules. Write down the correct data (teacher moves around). You first start by writing the correct data. It seems as if most of you are experiencing a problem. Could any one of you maybe try and help us on how to solve this one. Who can come and try and help us. Start by writing down the correct data and after show us which variable you are trying to calculate. Who can come any volunteer can come, come. (one learner sits up and goes to the board). Make sure you watch exactly each and every step he tries to do to enable us solve that problem.

Learner : First write the given data we are given:

$a = 8m/s^2$ and then the given time

$\Delta t = 40c$,

Teacher : s not c

Learner : We are trying to find Δx.

Teacher : What does the question asks?

Learner : Calculate how fast.

Teacher : What is that?

Learner : Final velocity and the equation will be $V_f = V_i + a\Delta t$

Teacher : Do you agree?

Class : Yes.

Teacher : How many of you got this? (whole class raises their hands). Thank you very much. Let me show you. Then we are getting final velocity. Calculate how fast it will be travelling. Remember initially it was travelling from rest, rest position. I'm happy you were able to detect that if it was travelling from rest it means the initial velocity is zero, then we were able to identify the unknown variable. Then we were able to get the final velocity as 320 m/s. then is it enough, if you get 320m/s are you going to get everything, all the marks? Ok who can just tell us? Is velocity a vector or scalar quantity? No singing.

Learner : Is a vector.

Teacher : Is a vector quantity, so what is required for us to do if it is a vector quantity?

Learner : We must add downwards.

Teacher : Do you agree as he saying? Do you agree? Downward. Could you please read the statement for us Nkosinathi, read the statement for us.

Learner : Reads the statement.

Teacher : Down a runway, accelerating down a runway, right. Accelerating down a runway. Maybe the correct one we can say in the direction of motion. Ne or we can even say down a runway. That will be the direction. Then the last thing we have is

V_f = 320m/s in the direction of motion. Lets do the second one (teacher writes on the board)

A car is travelling along the road at 8m/s it accelerates at 2m/s^2 for 3s. Calculate the displacement

which the accelerating car covers.

Teacher : If there is something, you cant see please let me know. Are you finished? Please make sure you write very fast.

Class : No

Teacher : Are you finished,……………………are you finished? One of you come and identify for us write down the correct variables and also write down the correct formula. Alright who can come and do this one for us. Sipho you can do this one for us. Come forward identify the correct values the given values and write down the unknown. (learner writes on the board). In the mean time you also do it on your own. Please speak up. You are not asking any one. The teacher walks around and check what learners are writing. You have forgotten the formula. Make sure you learn this form by heart, so that even when you are sitting for the exam you know what you are trying to search for. But first of all make sure you learn this equations of motion by heart. Discuss this among your friend to be able to write the correct formula. It will make this much easier. Please let's help her so that we can finish (referring to the learner writing on the board). (phone rings from one of the learners). Alright let us see. Are you all getting this one?

Class : Yes

Teacher : Are you all getting this one, some of you are not getting this one, but let's first try and look at the data, V_i, is V_i our initial velocity there, yes the car is travelling along the road at 8m/s. definitely is the initial velocity, it accelerates at *2m/s*^{2} for 3s. calculate the displacement. *2m/s*^{2} is the acceleration and Δt is 3s is the time and we are trying to calculate the displacement. Then is there any formula to use? The equation to use is

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$\Delta x = 8*3 + ½*2*3^2$

Δx = 33m

So we are given time 3s, initial velocity is 8m/s, we are also given the acceleration *2m/s*^{2} and the time as 3s. so 8 multiplied by 3 is 24 and 3 squared is 9 and ½ multiplied by 2 is 1 and therefore 24 + 9 = 33m. Is there any one of you who have used another formula but getting the same answer, is there any one? Ok let us do the last one. There after I'm going to give you some of the problems to do in addition to the one as a classwork.

A minibus is travelling at 15m/s. when a robot 30m away changes to orange the driver brakes hard

to stop in time. Calculate his acceleration.

This is the last one. The teacher walks around also distributed homework papers. Are you finished, who can come and try this one. Come and write down the data, come and write down the data. Are we finished? If not finished make sure you finish up. A learner goes to write on the board.

Teacher : Where is the formula? You have just done the substitution but where is your formula? What do you say? From her data what do you say about the formula? Is the formula correct. Jabu

Learner : There is no Δx there.

Teacher :Δx has to be Δt if we use that one. You uh… you heard?

Learner : No

Teacher : Δx has to be Δt if you are using that formula. Then what can you read the formula. No no can you read aloud the formula.

Learner : V_f………

Teacher : No, no can you read the formula aloud

Learner : $V_f^2 = V_i$

Teacher : Repeat once more

Learner : $V_f^2 = V_i^2$

Teacher : Exactly. Is that what you have written? Can you please help? What is your V^2? What again?

Class : 212

Teacher : Ok. Then what is…………………………No don't be afraid do what you know don't be afraid. It seems like you are dividing one side by 60. Is it what you are doing in your Maths. Don't be afraid no one is going to bit you. It seems as if you are experiencing problems. Right what is the answer?

: There was no answer

Teacher : Right let's read the statement. I am happy because you have indicated the units and they are correct. A minibus is travelling at 15m/s. when a robot 30m away changes to orange the driver brakes hard to stop in time. Calculate his acceleration. So it means the final velocity is zero because the driver brakes hard to stop in time. Why is the acceleration negative? Who can just tell us?

: There was no response.

Teacher : But why is our acceleration negative. Is acceleration a vector quantity or a scalar quantity?

Class : Vector

Teacher : A vector quantity. Why do we say acceleration is a vector quantity? Nkosinathi.

Learner : It has got magnitude and direction.

Teacher : It has got magnitude and direction. So but now why is our acceleration negative? Who can just tell us? Thando.

Learner : Because the driver applies the brakes

Teacher : The driver is applying brakes, so that makes our acceleration to oppose the direction of motion of the minibus. The velocity of the minibus is still forward but the acceleration is backward that is why our acceleration is negative. But do we leave our answer as negative just like that? Who can just tell us how do we write our answer? Who can just tell us? How do we write our answer? Innocent.

Learner : Acceleration is 3.75m/s^2 in the direction of motion.

Teacher : Let me ask you this one do we leave our acceleration as negative just like that? What do you say yes or no? who can just help us. Nothando.

Learner : No

Teacher : No, so it means we have to write it as positive and what do we do once we start writing it as negative? What do we do? What do we do? Yes Thathu.

Learner : 3.75m/s^2 backward.

Teacher : 3.75m/s^2, then backward or opposite the direction of motion. Opposite the direction of motion. Please try and do because of time example no 1. Question 1 in that paper that I have just given to you right now. Do no 1 as quickly as possible and try to do no 6. I want to see how you do no 1and no 6. Hope everybody has got this sheet of questions with him or her. I want us to do only 2 no 1 and no 6. I want to see how you do no 1 and how you do no 6. Please. So which means there is no need for you to copy these problems again. Simple write down the correct data down because these are just with you. I want to see how you write the correct data and how you identify the correct formula (Learners were given time to write and were allowed to discuss among each other in small groups).

Teacher : Lets see the first one, how did you do the first one? How did you do the first one? What is the correct data? The car is travelling at 2om/s. what is 20m/s?

Class : Initial velocity

Teacher : Initial velocity is 20m/s. Right it accelerates at 0.5m/s^2. What is 0.5m/s^2?

Class : Acceleration

Teacher : Acceleration is $0.5 m/s^2$ and for 30s. What is 30s?

Class : Time

Teacher : Time is 30s then calculate how far it will travel in this time. How far what is that?

: There was no response

Teacher : Delta x ne.

Class : Yes

Teacher : So which formula did you use?

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ substitute

$\Delta x = 30*20 + ½*0.5*30^2$

$\Delta x = 825m$

Teacher : Is there any one who have used another formula

Class : No

Teacher : Maybe you will try and do that one later. Before that lets do the second one it will be very short. Lets do the second one. Be patient. It's the only time we are having. Please.

Class : Yes.

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TRANSCRIPT

LESSON OBSERVATION

MR MALINGA'S LESSON 2

SUBJECT: Physical Sciences

GRADE : 10

TOPIC: WAVES SOUND AND LIGHT

Teacher : Good day class, today we will be talking about waves, sound and light. This is something also that we experience in our daily lives. So it is also very important that we also learn how to understand, how we can, how it can benefit us and the problems that we encounter as a result of such that is wave, sound and light. We know we have got other waves because we are not going to deal with everything at the same time but for today we are going to talk about waves. We have got two types of waves that we know of. Who can just remind us?

Learner : Transverse waves

Teacher : Transverse waves, and we also have what?

Learner : Longitudinal waves

Teacher : Longitudinal waves, longitudinal waves. Who can just give us examples of transverse waves? Examples of transverse waves. We come across examples of transverse waves in our lives. Thando.

Learner : sea

Teacher : The sea has what? Yes we talk of transverse waves, water waves. What else are examples of or can be used as examples of transverse waves. Waves which are also transverse in nature. Thoko.

Learner : Sound waves

Teacher : Sound waves as we are talking. Sound waves are they transverse in nature? Are they transverse in nature? Sound waves are longitudinal in nature. Ok. So they are longitudinal, they are examples of longitudinal waves. So what other examples are examples of transverse waves?

Learner : Light waves

Teacher : Light waves, ok. The different waves that are coming from the sun we know there are seven different rays that are from the sun. Can you name them? Examples of……

Learner : radio waves

Teacher : radio waves. What else?

Learner : gamma rays

Teacher : gamma rays

Learner : x-rays

Teacher : x-rays

Learner : ultraviolet rays

Teacher : ultraviolet rays

Learner : microwaves

Teacher : microwaves

Learner : infrared radiation

Teacher : infrared radiation

Learner : visible light

Teacher : visible light the one that enables me to see you, the other one. All those are examples of transverse waves, ok. We are going to focus today on transverse waves. Who can tell us if we just put a stone into water, or in the river? What happens? What do you observe? If you just throw a stone into the river what do you notice? Jabu.

Learner : We see waves, there are waves forms.

Teacher : Before we can talk about waves initially what happens? You are talking there, somebody is saying something. Jabu.

Learner : There are waves formed.

Teacher : But what happens then when immediately the stone hits there? What happens?

Learner : There will be a disturbance.

Teacher : Very good. There is a single disturbance, ok. What do we call that single disturbance? Zulu please you are too busy wait. What do we call that single disturbance? Mathews.

Learner : Pulse

Teacher : The pulse, a single disturbance we call it a pulse, a pulse. Let me ask you this one. What do you know about a transverse pulse? A transverse pulse? How is a transverse pulse propagated? How does a transverse pulse move? How does a transverse pulse move? Thando.

Learner : It moves through a medium.

Teacher : Of cause it moves through a medium. Most waves are transmitted or travel through a medium, travel through a medium, but how is a transverse wave propagated? How is a transverse wave moving? There is a disturbance, there is a transverse wave, how do they move? There is a disturbance of the transverse wave, there is a direction of motion of the transverse wave, how do they move? In the same direction, opposite direction or how?

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Learner : The pulse move in the opposite direction.

Teacher : Yes, but not necessarily in the opposite direction. They will move like this (draws on the board). This will be the direction of the pulse. The direction of motion of the pulse (showing the direction with an arrow on the board). Alright, ok. The direction of motion of the transverse wave is this one (also showing by an arrow on the board). This one is the direction of disturbance, upward. The direction of motion of the pulse of the transverse pulse is forward, while the direction of the disturbance is at right angle to it, ok, and they are 90°to each other. That is what you need to understand. So you need to understand how a pulse, what a pulse look like. This is an example of a pulse (draws on the board), that's how a pulse looks like. A single pulse right. Who can just tell us what do this distance from here to here? It is the pulse length not necessarily the wave length. So what about this one? Monica.

Learner : Amplitude

Teacher : Is the amplitude. What is the amplitude anyway? What is the amplitude? I hope you are not referring anywhere. Close everything. What is the amplitude anyway? What is the amplitude? Zinhle.

Learner : Is the maximum distance of particles from its equilibrium position.

Teacher : Let me write it down. Yes that is the amplitude, ok. That is the amplitude.

Learner : Is it not displacement?

Teacher : Displacement, we can put it in the same way because that disturbance is taking place up, we can say is displacement, displacement is displaced upward. So thank you very much. So we are talking about disturbance. Then we don't have one single disturbance in nature. There are lot of disturbances. Then you find that these disturbances will at times come and meet. You find that there is a disturbance taking place, there is also another disturbance taking place but you find that at times these disturbances, these pulses are moving towards each other and the disturbances will be taking place at the same place at the same time. The disturbances of the pulses will be taking place at the same position at the same time. Then we talk about the superposition of waves. Understand?

Class : Yes

Teacher : Right, you find that there is this disturbance or they move towards each other, these pulses as disturbances as single disturbances when they meet they combine. Remember this one has got its own what? This one has got its own what? (pointing on the board)

Class : Amplitude.

Teacher : Lets say it's a, and this one has got its own amplitude let's say its b, neh.

Class : Yes

Teacher : When they meet at the same point at the same time, what do we call that principle?

: NO response

Teacher : The principle of superposition of waves. All of you.

Class : The principle of superposition of waves.

Teacher : This is what is going to happen when they meet at the same place at the same time. We say the amplitude of a plus the amplitude of band we get the result of the two amplitudes, a + b, neh.

Class : Yes

Teacher : And we are saying the principle we call it the principle of superposition of waves.

Class : Superposition of waves.

Teacher : Superposition of waves. Let us say you move towards each other. You want somebody move towards you. Are you comfortable with that?

Class : No

Teacher : Somebody moves towards you, are you comfortable with that?

Class :No

Teacher : You are not comfortable, but it happens with waves they move towards each other. When they move towards each other we say they interfere. We say they do what?

Class : Interfere

Teacher : interfere and the process is called interference. So when they pass each other we say they interfere and the process is called interference when they pass each other. Then now there are two types of interferences. Who can just remind us? Nkosinathi.

Learner : Constructive interference

Teacher : Constructive interference. There is also what? Zinhle.

Learner : Destructive interference.

Teacher : Destructive interference, neh.

Class : Yes

Teacher : So when are we going to experience constructive interference for these single disturbances, for these pulses are single disturbances. When are we going to experience constructive interference. Yes Thando.

Learner : When both pulses are positive

Teacher : When both pulses are positive, in which way?

Learner : Both positive.

Teacher : Ok even if you can put that one is understandable, but like these for instance could be good examples. The crest of one pulse meet with the crest of another pulse. Then what is going to be the result will be constructive interference. Is that the only case? What if we have got this one. A situation like this, these pulses can you see the pulses are upside down. What do we call this one by the way? We call this one the what?

Class : Trough

Teacher : The trough. This one is the what?

Class : Trough

Teacher : The trough. You see now you have the situation where these pulses are moving towards each other, they are upside down. The trough of one pulse meets with the trough of another pulse. What do we call the process here? What type of intereference is taking place here. Just raise up your hand. What type of interference is taking place? What type of interference is taking place? Yes Innocent.

Learner : Destructive

Teacher : Destructive interference, do you agree? Thando, what do you say?

Learner : Constructive interference

Teacher : Is constructive interference, neh.

Class : Yes

Teacher : Is also constructive interference, neh.

Class : Yes

Teacher : Ok, you can see that these pulses or these troughs are on the same side and these were also on the same side. Then let's say we have got this situation where we have got a crest of one pulse meeting with a trough of another pulse. They move towards each other, so they interfere with each other. What type of interference are going to experience with this one? What type of interference?

Class : Destructive interference

Teacher : Destructive interference. What if let say the amplitude of this one was 2cm and the amplitude of this pulse was also 2cm. What will be the resultant amplitude or resultant disturbance? What do you think? No just raise up your hand, Thabo.

Learner : It will be zero

Teacher : Zero, it will be zero. That will be point of no disturbance, it's a place of zero distiurbance, cancellation of both pulses. Isn't it? So we have talked about superposition as appoint where these single pulses as single disturbances they find themselves at the same point at the same time. They find themselves making the same movement at the same time neh.

Class : Yes

Teacher : Ok right. Could you, let us do this one. It is also very much important that we know much better about this transverse wave so that we can know how to overcome problems we encounter in our daily lives. (The teacher labelled points on the drawing of a transverse wave on the board as Q, X, Y, Z, K, T, AND V). Alright who can just tell us just label the part which is written 2cm. That is? What do we call the part written 2cm, that line there (Teacher points on the board). That one, that line labelled 2cm in length? Zulu.

Learner : Amplitude

Teacher : Amplitude, Ok right. Then what can you say about this line from here up to here? What is it that equal to if we add and ignore the signs? If we just add what is it equal to? How many cm?

Class : 4cm

Teacher : 4cm, how does it relate to the amplitude of the wave? How do they compare? How does that line compare to the amplitude of this wave? How? Which one is greater which one is smaller?

Learner : They are opposite

Teacher : come again

Learner : They are opposite

Teacher : But we said ignore the signs, from that up to the maximum point. We said is equal to what?

Class : 4cm

Teacher : 4cm, and the question is how does that 4cm compare to the amplitude of this wave? That's what I was asking can you try it. Can you try it Nkosinathi?

Learner : The amplitudes are equal

Teacher : The amplitudes of cause they are equal, but how does that 4cm compare to the amplitude. Come.

Learner : It is 2 times

Teacher : The 4cm is 2 times the amplitude. Can you see that?

Class : Yes

Teacher : At times you may be given the distance from the trough to the crest, the maximum point, and assuming or thinking as if that is the amplitude while that one is not the amplitude but that one is 2 times the amplitude. Neh. Alright. By the way what do we call the distance between two points in the wave which are in phase? These one (Teacher points on the board). Luyanda.

Learner : Crest

Teacher : We call it the crest do you agree.

Class : No

Teacher : What do we call it? Thathu

Learner : Wavelength

Teacher : Yes it is the wavelength. What is the wavelength by the way. We said what is the wavelength? Thathu.

Learner : No response

Teacher : What is the wavelength? You don't know the wavelength. What is the wavelength? Zulu.

Learner : Distance between two points.

Teacher : It means you have got this point and you have got this point (Teacher pointing on the board). Once you have the distance between the points, so we call it the wavelength. Do you agree?

Learner : No

Teacher : Alright, so which one then? Zinhle.

Learner : Is the distance between two points in a wave which are in phase.

Teacher : Is the distance between two points in a wave which are in phase. Can you give examples of points which are in phase. First two points which are in phase. Immanuel.

Learner : Q N

Teacher : or EN or QF. Other points? Lindokuhle.

Learner : BT

Teacher : BT, these are examples of points in phase. Just give me examples of points which are out of phase. Msibi.

Learner : VF

Teacher : What?

Learner : VF

Teacher : Yes VF are examples of points which are out of phase. Then as I was just talking and telling you that we need to understand these waves the properties of these waves much better. That is what we are trying to do. We want to understand more about the waves. What do you understand by the period of a wave. Period of a wave. If we talk about period, period is something that has to do with what? Period that has to do with time. What is period, or period of a wave? What is the wave doing that we have to talk about the period of a wave. What is this wave doing? Nkosinathi.

Learner : Time taken to complete one full vibration.

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Teacher : Repeat neh. Time taken to make one full wave neh, time taken to make one full vibration. That is period. Time taken to make one full vibration. Alright what is the symbol for period by the way? What is the symbol for period. Ayanda.

Learner : No response

Teacher : Symbol for period, Thathu.

Learner : T

Teacher : Just T, just T

Learner : Capital letter T.

Teacher : Capital letter T, right. Then what about frequency? What about frequency of the wave? The frequency of a wave. What do we mean by frequency of a wave?

Learner : The number of vibrations.

Teacher : The number of vibrations taking place per second. The number of waves, the number of complete waves per second. The number of complete waves passing a point per second, neh. Ok. What is the symbol for frequency? What is the symbol for frequency?

Learner : Small letter f.

Teacher : Ok small letter f. What are the units for period? The units for period. Ayanda.

Learner : Seconds

Teacher : Seconds, seconds. What are the units of frequency? What are the units for frequency? Zinhle.

Learner : Hertz

Teacher : Hertz, Hertz, captal letter H and small letter z, right. Lets continue, by the way how are these frequency and period related to each other. Who can just give me an example of how these frequency, these quantities are related to each other? Frequency and period.

Learner : There are formulae

Teacher : Formula as what?

Learner : $f = \frac{1}{T}$

Teacher : Then the other one $T = \frac{1}{f}$, but what, how do you relate, what is the relationship between frequency and period. How are they related. Lets say the period, we increase the period by 2 or we double the period, is the frequency also going to be doubled?

Class : No

Teacher : How are they related? That's what I want, how are they related? If we increase period is the frequency also increased?

Class : Yes

Teacher : You are trying to say it decreases neh.

Learner : Yes

Teacher : So what is important is that you must know how it decreases. The period is T and the frequency is f. the period is capital letter T and frequency is f. as they are written like this $T = \frac{1}{f}$ it means if one increases the other one decreases.

Class : Yes

Teacher : So what do we call such relationship? What do we say to such relationship? What do we say? They are what? Such relationships. Let us say if one increases the other one also increases, what do we say to such relationships? They are said to be what? There is a certain term that we use. We say they are………………… they are directly proportional to each other. But these two frequency and period are inversely proportional to each other. Understand. If one doubles the other one will decrease by that factor. If one is 2 times greater, the other one will be 2 times smaller. Understand. Let us continue. Lets come to the other relationship which will enable us to calculate the speed of the wave. Right this one, I hope this one is not new to you. Ok. What is the formula for the speed of a wave. Who can just remind us? Any formula you know. Its not for the first time that you are talking about this formula V for speed, V is equal to what? Jabu.

Learner : $v = \frac{\Delta x}{\Delta t}$

Teacher : $v = \frac{\Delta x}{\Delta t}$ neh, this we can still use as the speed of the wave. Is there any other formula that we can use?

Class : yes

Teacher : Right let's see

Learner : $v = \frac{\lambda}{T}$

Teacher : We are talking about waves. So waves, the units of waves λ, what are the units of λ?

Class : metres

Teacher : What are the units of T, the period?

Class : seconds

Teacher : seconds. So what are the units for this speed of the wave?

Class : metres per second (m/s).

Teacher : metres per second, and what about this one $v = \frac{\Delta x}{\Delta t}$

Class : metres per second (m/s)

Teacher : Is there any other formula that we can use to calculate the speed of the wave? Just tell us. What is that formula? We can derive the formula from this one. What is the formula?

Learner : $v = f\lambda$

Teacher : We know that $f = \frac{1}{T}$, which means this is the same as $v = \lambda.\frac{1}{f}$ that means we can write as $v = f\lambda$. Let us see if you can use these examples. Try to do them on page 110. I hope it's the last examples. How many have these textbooks? Please sit where there is a textbook. Right. There is an exercise on page 110 number 1.

The wavelength of a wave is 10m. if a crest of the wave pass every 20s, calculate the wave speed.

Teacher : Remember how we do it we start by writing down the data. Write in your exercise books. I want to see how you write down your correct data. You can't just choose a formula without writing your correct data. (teacher walks around checking learners work). Please how many of you are having the textbook? Please sit next to those who are having a textbook (learners moved to form small groups sharing textbooks). Are you finished?

Class : Yes

Teacher : Who can come and do this one for us? Zulu, can you please come forward and do this one us. Start by writing the correct data and there after show us how to calculate. Come forward. I hope you are finished and watching what he is doing now.

Class : There were some dissatisfaction in disagreement with what she was writing.

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Teacher : The problem you are listening to others. Alright, what do you think is the data correct?

Class : Yes

Teacher : v is what we are trying to calculate, and the wavelength we are talking about the distance covered by the wave here. Do you agree with this one? Are you all getting this one?

Class : Yes

Teacher : So then if you agree its correct. Then let us do the second one. Who can do the second one? May it seems as if you are going to do the second one for us. The last one, who can do number 3a and number 7. Please come and do the second one for us, May come and do the second one for us. If you are finished with the second one move to the third one. Alright. Are you all getting this one. Let me see. In the meantime, who can do number 3a for us? Dumisani do number 3a. Please finish up. Are you finished with number 3a? Please finish up.

Alright I can't see you f, make sure you write your f on your left as your answer. Ok are you all getting 20Hz?

Class : Yes

Teacher : But I hope most of you could not recognise that when you are given wavelength in millimetres you have to change the millimetres to metres, before you could calculate the frequency. Then do number 3b, do number 3b, somebody do no 3b for us.

Ok Thando got 0.05, what I can't see what were you calculating. What wre you trying to calculate? What does the question say?. Ok did you get this one?

Class : Yes

Teacher : Did you all use this way?

Class : No

Teacher : Maybe who did not use this one must come and show us, come. Use another method to see if you will get the same answer. Don't erase that.

That is how we use a different way but even that one of Thando is still right. Thando was able to get the correct answer but using a different formula, right. I think you are going to do number 4 as homework neh. You are also going to do number 2 as homework neh. Thank you very much.

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TRANSCRIPT

LESSON OBSERVATION

MR MASHABANE'S LESSON 1

SUBJECT: Physical Sciences

GRADE : 10

TOPIC: NEWTON'S LAW OF UNIVERSAL GRAVITATION

The teacher: The teacher the visitor. We have a visitor today in our classroom. There is some work he has come to do and request that we assist each other and learn together.

Right : Our today's topic reads as follows Newton's Law of Universal Gravitation, so we are going to focus much on this law were at the end we must be able to calculate some forces which maybe they will need us to calculate. First of all let me say each and everyone of us must be able to state the law and must also be able to write down the mathematical of the law. So the law states that let me say for example there are two balls A and this one ball B .According to this law it says these two balls are exerty or maybe there is a force between the two balls, this object exert a force on this one and this exert a force on that one. At the end we must be able to come out or maybe calculate that force. So the law states : Let me start with this law: Newton's Law of Universal Gravitation states that every particle in the universe attract other particles with a force that is directly proportional to the product of their masses and inversely proportional to the square of the between them.(Written on the board) right the teacher reads the law.

From the there are two key words which are very much important directly proportional and inversely proportional. Lets first of all try understand these two words. What does the word directly proportional mean? And also what does the word inversely proportional mean? So that from there it is where we can start maybe playing with these concepts, with these topics. Let us start with the word directly proportional, what does that mean if they say something is directly proportional to something. The word directly proportional means? Directly proportional, what does that mean? When let us say someone talks of directly proportional. Right let us say maybe for example we do have a graph of X and Y and we have to some value, I want to show you some about directly proportional (draw a graph with the axes in a straight line pairing through the origin).The teacher pointed to the learner that the values of X increases so does the values of Y.

Teacher : If X is here what will be Y.

Class : 2,1,6,1,7

Teacher : Is it, if X increase 1,5,16

Teacher : So what can we say about the values which X increase what about Y?

Class : Increase

Teacher : Y increases

Teacher : So when we talk of directly proportional we are saying, where one variable increase the other one also increases. Therefore we say there two variables are proportional to each other because when Y increase also X increases. Right let us come to this one inversely proportional. If someone talks about inverse proportion that someone is trying to tell us what?

Teacher : I can not hear you? Inversely proportional.

Learner : Decreases.

Teacher : Inversely proportional, if you say decrease, what decreases? Alright, alright my friend let us say we have a graph which looks like a parabola. Same method, same way. (The teacher showed on the graph that where one variable increases the other decreases.)

Teacher : if in here (pointing on the graph)the value of Y is?

Class : Three (3)

Teacher : the value of X

Class : Where

Teacher : Is that one; one (1)

Class : Yes.

Teacher : So by mere looking what can we say about the curve?

Teacher : The relationship between Y and X concern to reach focus much on that curve

Class : When Y increases X decreases.

Teacher : When Y increases X decreases.

Teacher : When Y decreases X increases.

Teacher : That is what we are saying inversely proportional means that when one variable increases the other one decreases, because from zero upwards X is increasing but from 3 downwards Y is decreasing. Right so from the we can have maybe, let me write this. We are the force between the objects is directly proportional to the product A the and proportional to the square of the substance between them

F m1 m2/r2

Let me ask you something, When force decreases the increases. When force decreases the do what?

Class : Decreases.

Teacher : They are inversely proportional to each other.

Teacher : Right let me say double one of the maybe M2 will the force double, half or

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Triple. We are doubling of the will this one (F) increase or decrease?

Class : Increase

Teacher : Right let me say now I am doubling this the (2r),will force increase or decrease?

Class : Decrease

Teacher : The force will decrease. So mathematically

F G M1 M2/r2 where we include even the gravitation contant.

That is the formula which we are going to use to calculate the force between two objects

Teacher : Then from these let me show you the trick of this topic. You will be given. Let us say you have this 120g it a ball then this one 360g

The distance between their centres we say right is r ,our r, let me say our r maybe is 10 mm. In other work let me start by saying this formula make that always our is measured in kg, then our distance always m not cm or mm. If we are given some values to calculate the force check that are the in and are the distance in m. If it is in that it means you must start changing our r to into m. Then from there G is constant we know if maybe you can check from the book we are given that G= 6,7 x10 N.M.kg right. Then from there they can ask you to calculate the force between objects A and object B. So let us check first are the in kg.

Class : No

Teacher : So we have to charge the g into kg. Then from there let me start by saying we also have mg eg dg hg kg. Right we are given the first one 220g,we want to change g to kg then from there which number are we going to multiply with or which number are we going to divide with to change g to kg.

Class : 1000

Teacher : We divide, we multiply, are, we subtract

Class : We divide.

Teacher : We divide, so it means we are going to have 220/1000 kg then we indicate kg. Then it gives us what? 0.22Kg. this is our mass A. Then mass B we have 360g, then if we are here we say 360/1000 kg, then it gives us what? 0.36Kg. What about this one the distance. Our distance is in mm. We want to change it from mm into?

Class : Metres

Teacher : Into metres. What do we do?

Class : We multiply by 1000

Teacher : We multiply by 1000. If you say we multiply

Class : We divive

Teacher : We devide. You can write this its mm, cm, Dm, m, dm, hm, Km. Then you can decide if you want this I can divide by this. In mathematics you can be given kg and they say change kg into g then you can see from there to there. I can multiply or divide. Right our r now becomes what r=10/1000 m we divide by 1000. Why always by 1000. Its equal to 0.01, then we get what? Then from there we know our masses are in Kgs our distance in m, therefore we can calculate the force.

$$F = \frac{GM_A M_B}{r^2}$$

$$F = \frac{6.7x10^{-11}x0.22x0.36}{0.01^2}$$

Class : G is $6.67x10^{-11}$

Teacher : Right the book I am using says 6.7, but no problem. (The teacher corrected and used the 6,67 in the calculation). Someone with a calculator help us. It is problematic maybe to most learners when using a calculator for these problems, because some will say is 6.67 x 10 to the power -11 and the answer might not be the same if you press 6,67 EXP -11 and continue. The answer hereis?

Class : $5.3x10^{-8}$N

Teacher : Tell me why I have written N there.

Class : Force

Teacher : We move from, let me say maybe we have written units of G we will have $\frac{Nm^2Kg^{-2}.Kg.Kg}{m^2}$ we have this units. Who can simplify this. You need not crame that force is measured in Newtons. You can get issues like momentum were you have concepts like impulse. Mathematics dividing same exponents and multiplying same exponents. Right in this one, we know our force is measured in N. so we have got these units so what do we do? Why at the end we are going to end with N only?

Class : They cancel each other.

Teacher : they cancel ok, but let's do it exponentially

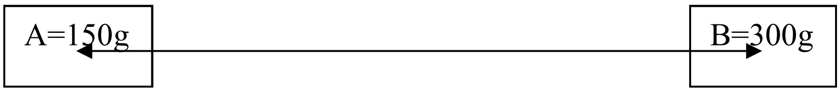
$\frac{N.m^{2-2}.Kg^{-2+2}}{}$ the 2-2 gives us what?

Class : zero

Teacher : Any number to the power zero is?

Class : 1

Teacher : 1 not zero, then we will have $N.m^0.Kg^0$. That's why we will have N, any number to the power 0 is 1. Rights guys and ladies lets' go ahead where maybe we do have these. Let's call this one maybe example no 2. Let me say we have got maybe two bricks, the first brick has the mass of 150g and the other one brick has the mass of 300g and the distance from their centrers is 20cm.



20cm

Then they say calculate the force which brick A exert on brick B. Who can do that? Find the force between these blocks. Who can calculate the force?

Leaner : A learner goes to the board to do the calculation.

Teacher : Our photocopier is not functioning, I could not make copies for you. You can talk to the class Malambe, because maybe if they can hear from you they can understand better than when from me. r=20/100m=0.2m, M_A=150/1000=0.15Kg, M_B= 300/1000=0.3Kg

$$F = \frac{GM_A M_B}{r^2}$$

$$= \frac{6.67x10^{-11}.0.15.0.3}{0.2^2}$$

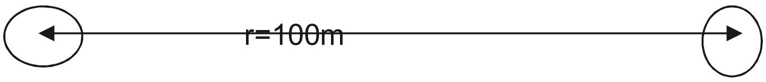
Teacher : Assist him what is the answer?

Class : $7.5x10^{-11}$N

Teacher : Right let's give him a round of applause please.

Class : Claps hands for the learner.

Teacher : Thank you Malambe. Right another trick about this topic, they can ask you let's say for instance we have two identical balls and the distance from their centres is maybe 100m. They are talking about two identical balls.



Right let me ask you this word identical, what are they saying?

Class : Same balls

Teacher : Same balls. Right the force which is exerted between the two let's say is 7.2x10-8N. Then they can ask you to find the masses of the balls, let's say this is A and that is B. Then find the mass of each ball. We are talking about identical balls. You say same balls. Now they say find the masses. Right from the formula

$F = \frac{GM_A M_B}{r^2}$ that is why I am saying you must not cramme that they will always find force. They will give you the force, you know G=$6.67x10^{-11}$, then they will ask you to find the mass or the distance. They can give you the mass then ask you to find distance or they can give you the distance and ask you to find the mass. Now they are talking of identical balls. Balls with the same masses. They need us to find the masses. Who can make the two masses the subject of the formula. Who can do the product M_A and M_B the subject of the formula. Right let's make the two products subject of the formula. I know you did this in Grade 10, because I am also teaching Grade 10 mathematics. Lets make the product M_A and M_B the subject of the formula. Hey guys and ladies I am not going to write the final examination you are the ones who are going to write. I am showing you the tricks of this topic. Its not always where they will say find the force, they will sometimes say find the mass where they talk of identical objects, or find r. in this one we need a girl because a boy has already written on the board. A girl come.

Learner : A girl went to write on the board.

$$r^2 xF = GM_A M_B$$

$$M_A M_B = \frac{r^2 xF}{G}$$

Teacher : Lets give her a round of applause.

Class : Claps hands for the girl.

Teacher : Then from there, let's play around with this thing. We know that the balls are identical. If we find one mass we would have found the mass of the other because they are identical. Then from what can we do. Let x represent the mass of object A and B, then we will have

$$M_A M_B = \frac{r^2 xF}{G}$$

$$x.x = \frac{r^2 xF}{G}$$

$$x^2 = \frac{r^2 xF}{G}$$

$x = \sqrt{\frac{r^2 xF}{G}}$ right we want to find the mass of each ball then we say let x represent the mass of one ball and we end up with this formula. Then from there we know our distance, we have been given the force, and we know the value of G, we can find the mass. Who can do that one. Its just a matter of substitution you substitute and use the calculator. Smallboy come. I need all of you to see.

Learner : one boy went to the board.

$$x = \sqrt{\frac{r^2 xF}{G}}$$

$$x = \sqrt{\frac{100^2 x7.2x10^{-8}}{6.67x10^{-11}}}$$

Teacher : Help him with your calculators, because he does not have one there.

Class : 3285.5Kg

Teacher : Are you all getting the same answer. Borrow Smallboy a calculator to do the calculation (laughter from class). Its not a play, you will get it in the control test and you will have forgotten how to do this. Lets listen to Bongani. What do you get? Or you need another calculator. Do it Bongani.

Class : We are getting different answers.

Teacher : Try to use the calculator correctly. Its important to ensure that you find the square root of the final answer. Let's proceed no problem, I will go to the maths teacher Mr Kwashi, we are not supposed to get different answers. Ok let's procced. We are saying $F \propto \frac{1}{r^2}$ sometimes they can ask you that if we half the distance by what factor will the force increase. Lets say our distance now is ¼, by what factor will the force increase if the distance is ¼.

Learner : I got that.

Teacher : You got it

Learner : No the previous one.

Teacher : Ok I told you the calculators are not the same. Just explain to us how you got it.

Learner : I said r2 multiplied by force, then the answer divided by G, then took the square root of the final answer.

Teacher : That means the formula shall be $x^2 = \frac{r^2 xF}{G}$, do you see that. You calculate and take the square root at the end. Right let's come to this one. We are saying $F \propto \frac{1}{r^2}$, if they are saying the distance is r=1/4, by what factor will the force increase.

Learner : By a factor of 16.

Teacher : Yes the force will be 16 times greater. These are the tricks you need to be aware of in this topic. Let's stop here for today.

TRANSCRIPT

LESSON OBSERVATION

MR MASHABANE'S LESSON 2

SUBJECT: Physical Sciences

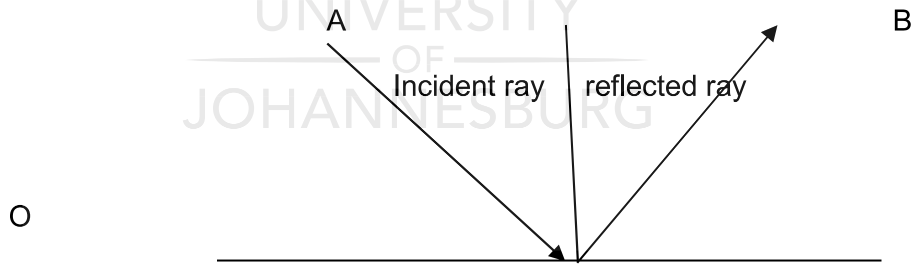
GRADE : 10

TOPIC: GEOMETRICAL OPTICS

Teacher : This is my period let's forget about the Life sciences. Right let me say today we are going to start a new subtopic, geometric optics. In this topic we are going to focus much on light. Let me say to you, mention anything you know about light. Light something you know about light. Someone can say I know the speed of light is $3x10^8$ m/s. something about light. Right let's focus on two concepts about light, we are going to focus on reflection of light and refraction of light. (someone came stood outside the class and spoke to the teacher for some few seconds). Then before we start anything what does the word reflection mean? So the word reflection. Who can tell us about the word reflection. Before we can say something about reflaction of light.

Learner : Rediation.

Teacher : Rediation, he said radiation. What is radiation? When you hit a ball like a tennis ball against the wall what will happen? It will come back. Then meaning that reflection is something like that. Let me say there are substances which can reflect light and others cannot reflect light. For example if we have a mirror. A source of light I mean a light coming from a source of light it can pass through the mirror it will be reflected.



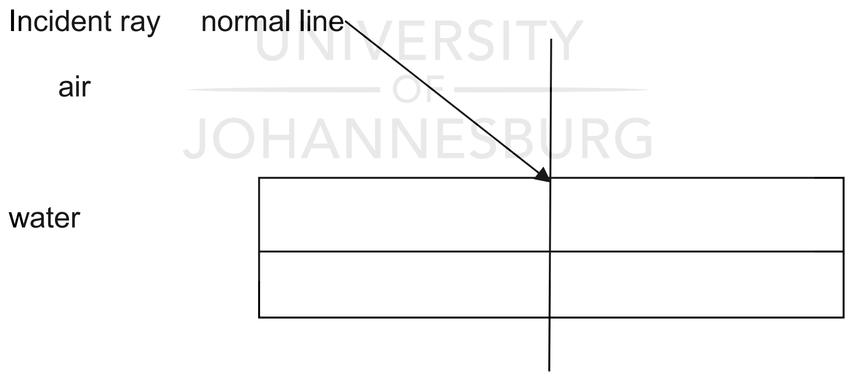
The is a line that controls us that line must be perpendicular to the surface of the mirror. This line is called the normal. It is the one that will control us. When we say we must know the name of the light coming from the source of light. Then we must know the name of this one after the light has struck the mirror. So this one coming from the source of light, let's say someone is holding a tourch. The light coming from the torch hits the mirror, then reflected. That light coming directly from the source we call it the incident ray. The one which maybe after the incident ray has struck the surface of the mirror, the one going away is no more incident ray, now we call it a reflected ray. Then if you check the incident ray hit the mirror at a certain angle. We focus on the angle between the normal and the incident ray. And we will also focus on the angle between the reflected ray and the normal. The angle which maybe the incident ray hit the mirror (**there was a disturbance again the same person who can at the beginning of the lesson came to talk to the teacher**). Then from there that angle let me use a i and that one between the normal and the reflected ray r, where we are saying sometimes they can describe as follows: ray AO and ray OB. We have said AO is the incident ray and OB is the reflected ray. Then the angle which is formed between the incident ray and the normal we call angle of incidence not angle of incident. Then from there the angle between the reflected ray and the normal we call it the angle of reflection. There is a law when we talk about the reflection of light. The law says, they call it the law of reflection. States that when light is reflected, the angle of incidence is always equal to the angle of reflection. So in other words if you are drawing reflection, the angle of incidence must be equal to the angle of reflection $\hat{i} = \hat{r}$ is what the law says. Then from there about reflection, let me say maybe we do have different objects. When we shine light on the mirror we will find that light is reflected. What about if maybe we are saying we let light shine on a black object. Is the black object going to reflect light or the light will be absorbed by that object?

Class: Absrobed.

Teacher: Is going to be?

Class : Absorbed.

Teacher : Why? Your problem is that you don't talk. Yes its going to be absorbed by that object. So that is why if maybe we can take two people, the one wearing a white suite and the other a black suite, we live them in direct sun light. The one wearing a black suite will say it is too hot and the one wearing a white suite will say no it is ok, why? Because light is absorbed in the form of heat energy. After that, that somebody will feel very warm because of that, but the one in a white suite will say it is ok. Right we will focus on objects that allow light to pass through them, those materials are called optical materials (media). Lets say we have maybe optical media. We say one medium but two optical media.



Right these are surfaces or objects that allow light to pass through them.

For example we do have this (showing a glass prism) that's why I asked someone to go and take this rectangular glass prism. This object can allow light to pass through it. My problem now is I don't have a torch, but I do think that maybe one of the days we will perform this experiment at the lab, because we do have that. I remember last year Ms Hlophe did do this experiment with you. She did something in this experiment. Right from Grade 10 work there are this two things which are very much important. Let me say we do have air as a medium, we do have water as medium, we do have glass as medium. Then from here we want to find out what is going to happen if light passes through two maybe moving from one medium to another medium. Its where maybe we are going to focus much on this word refraction. Right let me say we do have water. (points on the diagram and labell one medium air and the other water). The incident ray is coming from air a different medium and it hits water a different medium. We want to find out whether it will be reflected or refracted. Right we know that the speed of light when moving in one medium stays the same, it wont change. But immediately it hits a different medium it is from air now it hits water another medium. Where the light rays hits water it means it is from air and water is another medium what will happen? You find that the speed of light in air is not the same as speed of light in water. So the speed of light in water is too slow than the speed of light in air. Right let me say when I asked you something about light I was hoiping someone will say if there is no light human beings are blind. Do you know that?

Class: Yes.

Teacher : Because what happens? It means light ray hits an object then they are reflected back to our eyes, then we can see that this is a car, this is a cow, but without light people are blind. So with this one, we are saying when a light ray comes from a certain medium and enters another medium there will be refraction of light. That is caused by the change in speed of that light. In the air it is too fast, but coming into water it will be too slow. Then from there, there is a rule which says when light ray moves from a less dense medium to a more denser medium it will be refracted towards the normal. Vice versa, when light rays is coming from a more denser medium from there it will be refracted away from the normal. So remember that always. They will give you I remember last year I moderated some scripts from Grade 10, I have seen some struggling to draw something like this, were they were supposed to indicate whether the light ray bends towards or away from the normal. What you need to know is that when a light ray coming from a less dense medium and enters a more dense medium it will bend towards the normal. But if like this where the light ray comes from water a more denser medium and enters air a less denser medium it will bends away from the normal. When we compare the two angles the incident angle and the refracted angle, if we check the incident angle (î) and the refracted angle (r̂) which one is bigger?

Class: Refraction.

Teacher : Angle of refraction. Coming to this one (the first case) the angle of incidence is bigger and the angle of refraction is smaller.

Let’s say maybe we were given the angles î= 45°, r̂= 38°. Then they ask is this ray moving from a less dense to a denser or from a denser to a less dense medium? What can you say? Just check the angles.

Learner: From a less dense to a denser medium.

Teacher: It is coming from a less dense and entering a denser medium.

Then from there let’s come to this one or before this one let me say we are given a prism then maybe someone strikes the prism with an instant ray of white light. Then it will be refracted on entering the prism because the light ray will be travelling from air into glass and on exiting the prism now from glass into air. Remember what I said its white light. When this light comes out of the prism we are going to see different colours. We are going to see colours. Then how many are they these colours if you still remember? The colours are seven

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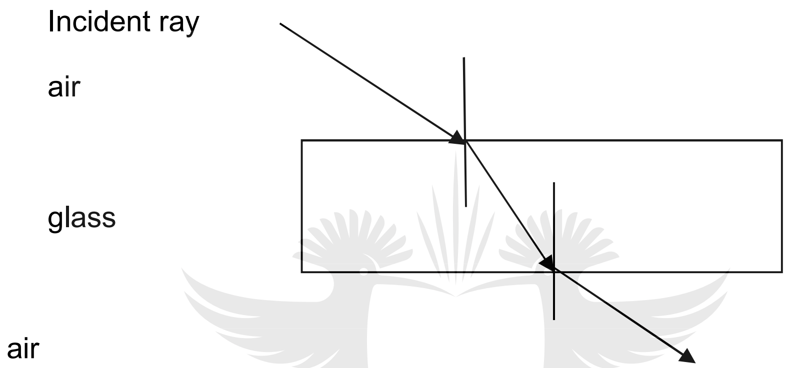
(ROYGBIV). When this light comes out of the prism we are going to see seven colours. Where the R stands for what?

Class: Red, O- orange, Y- yellow, G- green, B- blue, I- indigo, and V-violet.

Teacher : That's all, we are talking about white light. If they are asking about white light remember something like that.

But if maybe is blue sometimes they can use blue light, green light, yellow light. But what I am saying is that if its white light at the end we are going to see different colours. And if you write then you write them in that fashion. Then from there ah………let's come to this one as I have said it's a glass rectangular prism. So if let me say I hold it like this and strike it with a source of light, maybe a certain light green or something like that. Lets say instant light yellow or red, then from there. I am not good at drawings let's say this is glass and this is air.



Let me ask you something. We have said air is less dense and glass is denser. So will this one be refracted away or towards the normal?

Class: Away

Teacher: Away, it is coming from air which is less dense and is entering glass, and glass is more denser. So we said when light ray is coming from air and enters a more dense medium it bends towards the normal. Then from there we are going to have something like this (Drawing). Then let's have another normal like that. Then now it comes from a denser medium and approaches a less dense medium (air) will this light bends towards the normal or away from the normal?

Class: Away

Teacher: Away from the normal then from there we are going to have something like this (drawing). Then from here let's identify the angles. We have this angle between the normal and the incident ray which is î, angle between the normal and refracted ray which is r̂. Right angle between this refracted ray and normal is?

Class: i

Teacher: Its I which stands for?

Class: Angle of incidence

Teacher: Angle of incidence, from there angle between this ray and normal?

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Class: r

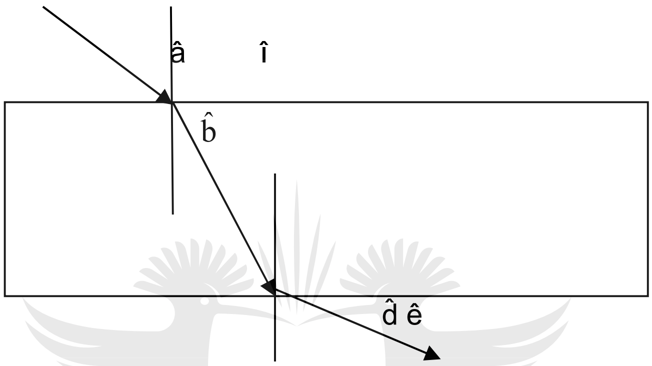
Teacher: Small letter r. then the name of this ray?

Class: Incident ray

Teacher: Right the incident ray. The name of this ray?

Class: Refracting ray.

Teacher: Refracting? Refracted ray. This one? This ray? This ray? Emerging ray. Right then from here. When they will want to ask you some questions, they will draw something like this,



then from there they will give you this let me say maybe they say this angle is â, b̂, and maybe ĉ, and say î= 45°and say give the magnitude of angle a, b, r, e, I mean you see the angles. Then from there we know we have drawn our normal which is perpendicular to the surface of this glass prism (rectangular glass prism). If î=45° what will be â?

Class : 45°

Teacher: What about r̂, can we find r̂, maybe if we say r̂=35°then we can find b̂, after that using alternating angles we can find the other angles. So we are going to write more exercises concerning this. My problem is one the book I am using I don't have the one you are using since you know we have a shortage of books. I am using one that is why maybe that has less exercises, but I will check what can we do. Then from there about refraction let me give you this information about it.

What is refraction by using what we have done. If you can be asked what can you say?

Refraction of light is the bending of light when light passes from one medium into another medium of different optical density. So it means if we compare air and water, air is a less dense medium and water is amore denser medium. So when light is coming from air and then enters water, then from there we are going to have refraction. Where we are saying is when light passes from one medium to another and that other medium have maybe a different density, then from there refraction of light is caused by a change in the speed of light at the boundary between the two media. We are saying where this water meets the air there is a boundary. When immediately the light moves from air and tries to enter there water is a boundary there and the speed of light starts to decrease, because we are saying light is faster in air but slower in water. So immediately it reaches the boundary, then is where the light starts moving slower and we know that from less dense to denser it bends towards the normal. Then we are saying at the boundary its where refraction starts to happen. Then other information is to say, light travels faster in the air than in the glass and water. It means glass and water are denser than air. So when light moves from air and it enters either glass or water, the speed will change. Refraction will then take place or when entering water light ray will be refracted because we are saying water got different optical density than air, air has got a different optical density. Then from there we can conclude by saying the higher the optical density, the slower the speed of light.

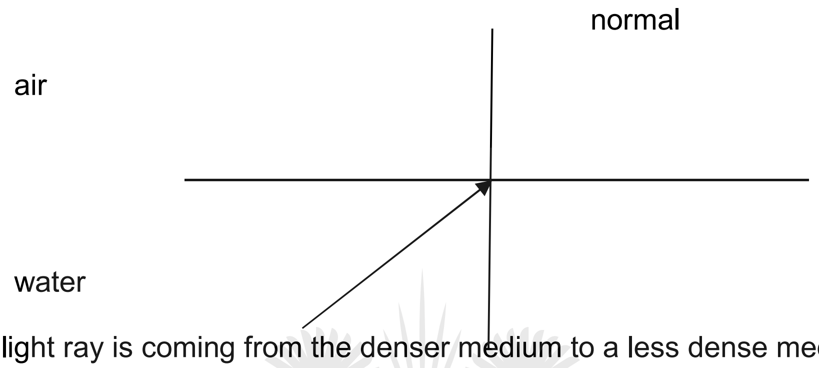
Right what about when we are talking about a vacuum. When a person talks about a vacuum that somebody is talking about what? A vacuum?

Learner: Space

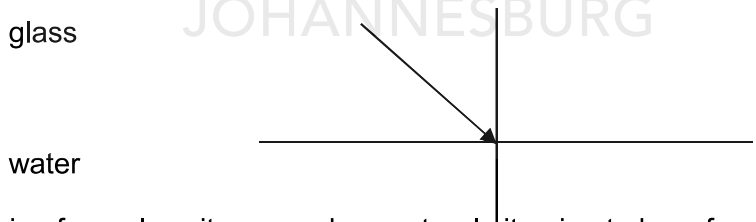
Teacher: Space, a space which is what? Which looks like what? Or is something or just a space. I mean this class, we can talk about space, so which space or what is special with that space. (There was silence for a few seconds). Right a vacuum it's a space where there is no air molecules and no air pressure. So if I can say a vacuum is the space, then you must maybe then say is a space where there is no air molecules, no air pressure. So a light travels or light has a maximum speed in a vacuum. When they say light has a vacuum speed in a vacuum it means the speed of light is what? Speed of light is $3x10^8$m/s. if they say maximum speed it means the speed of light in a vacuum is the one $3x10^8$m/s. Light has got maximum speed in a vacuum. Meaning that the speed of light is $3x10^8$m/s. It means in a vacuum the speed of light it will be this one, whereas in water the speed of light is equal ¾ of $3x10^8$m/s. You see it is not maximum in water. But in a vacuum it will be $3x10^8$m/s, but in water this is multiplied by ¾, then we get the speed of light in water. Then from there the ratio of speed of light in a vacuum to the speed of light in another medium material, v is called the refractive index: $n = \frac{c}{v}$, then from there when we go ahead when we going to talk about Snell's law. We are goingto use these refractive indexes. So what does the refractive index tells us? When a medium has got less refractive index what does that tells us about the light. So let me say we are given some media and also their refractive indeces, where they are trying to tell us something about the speed of light. Whether if the refractive index of air is higher or lower it tells us something about the speed of light. It means on that medium light will travel faster or slower? So we are given different media, for example we are materials like this : refractive index and materials

MATERIAL	REFRACTIVE INDEX
Air	1.00
Water	1.33
Ethanol	1.36
Paraffin	1.44
Perspex	1.49
Glass	1.52
Diamond	2.42

When the refractive index is bigger it means something concerning the speed of light. A bigger value of n (refractive index) indicates that the speed of light in that medium is slower. When the refractive index is bigger it means the speed of light in that medium is slower. Like saying if you check we have said water is more dense than air, if you check then in air n=1.00 and in water n=1.33. This means light is faster in air and slower in water. Then if you compare then you see that its going to be slower very small in diamond (n=2.42). One thing which I may say is those drawing where maybe they can ask you to indicate whether when you are given lines or rays coming from less dense to more dense or more dense to less dense medium, to finish or maybe to complete those drawings. Lets say for example you are given



A light ray is coming from the denser medium to a less dense medium and they say complete this. So you must know that if a ray is coming from a denser medium approaching a less dense medium it will be refracted away from the normal. Always make sure your normal is 90°, perpendicular to the surface. From more dense to less dense the light ray will be bent away from the normal. But if it is vice versa, if we are given :



The ray is coming from glass it approaches water. Is it going to be refracted towards or away from the normal.

Class: Towards.

Teacher: Towards, then let's compare which one is denser glass or water?

Class: Glass

Teacher: The refractive indices can help us because if you check they are saying the speed of light in air is maximum but in glass it is decreasing. So if you check glass and water. In which media will light travel faster between water and glass?

Class: Water

Teacher: Some say glass.

Class: Water

Teacher: So comparing the two which one is more dense and which one is less dense?

Class: Glass is more dense.

Teacher: Glass is more dense

Class: Yes

Teacher: Then water is?

Class: Less dense

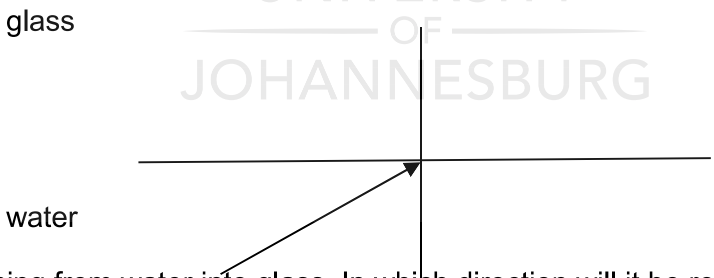
Teacher: If you have something like this it means the ray is approaching a less dense medium. So I am saying will this ray refracted towards or away from the normal?

Class: Towards, some say away.

Teacher: Ok give reasons if you say away reasons and if you say towards give reasons. Don’t be afraid. Im not going to write the examination. You are the ones who said glass is denser than water, then finish the diagram.

Class: Away

Teacher: That’s correct, it is refracted away from the normal. Since I have said, why we are saying that its because immediately the ray comes from glass and enters water, in water it travels faster than in glass, then as its starts moving faster it will move away from the normal. What about vice versa if we say now it is coming the other direction:



The ray is coming from water into glass. In which direction will it be refracted?

Class: Towards

Teacher: Towards the normal, from less dense medium to a more dense medium and the refracted ray will bend towards the normal, but from denser medium to a less dense medium it will bend away from the normal. Do you understand.

Class: Yes

Teacher: That’s all for today.

TRANSCRIPT

LESSON OBSERVATION

MS HLOPHE'S LESSON 1

SUBJECT: Physical Sciences

GRADE : 10

TOPIC: Chemical bonding

Teacher : Group numbers of elements in group I and II shows us the number of valence electrons of atoms of elements in that group. Let us look into these three elements

C N O

By the way we said carbon has 4 valence electrons, N and O?

Class : O has 6 valence electrons

Teacher : So now if we draw the Lewis structure we show only the valence electrons and those electrons are the once which will be involved during a chemical bonding.

A learner arrived late, and the teacher talked strongly to him.

Lets draw Lewis diagram for C. we said C has 4 valence electrons and we said what is the valency for C? Valence electrons ifs 4 and we said the valency for C is?

Class : 4

Teacher : The valency is 4, meaning C needs extra 4 electrons. What is the valency for N?

Class : 3

Teacher : 3 and for O?

Class : 2

Teacher : So it means if we draw the Lewis structure for carbon we will draw 4 electrons around C in such a way that all the electrons are unpaired. So that when the other four electrons come in during chemical bonding they will start pairing with the unpaired electrons (The teacher explains in SiSwati). So that C will have 8 electrons around it and when they are 8 all electrons will be paired. Lets go to N, N hast got 5 valence electrons. You start by indicating the 4 unpaired electrons around N

x

x Nx

x

How many are left now?

Class : 1

Teacher : We need 5. Then the 1 will start pairing. That means how many electrons around N are unpaired?

Class : 3

Teacher : That is why the valency for N is 3. Which means during bonding N is going to accept 3 electrons which will pair the 3 electrons. Lets go to O, O has 6 valence electrons. So how do you draw then when writing the Lewis structure? You first indicate the 4 unpaired electrons

x

x O x

x

Now how many paired electrons are we going to have around O?

Class : 2

Teacher : Yes because the 2 electrons will pair 2 electrons. Fluorine (F) in which group is F?

Class : 17

Teacher : How many valence electrons does it have?

Class : 7

Teacher : 7. Draw the Lewis structure of F. Into your notes book. If you are done draw for Mg, He and H. I will go around checking the Lewis structure for F.

The teacher went around interacting with learners. Learners were discussing in pairs in their desks.

Where do you get the small letter f for Flourine. Small letter f does not represent F. What did I say about Periodic Tables? Remember start by placing 4 electrons around F and then start pairing. Some of you have got it F has 7 electrons if done go to Mg.

Learner : A learner went to the board to draw the Lewis structure of F.

Teacher : Look how he is doing it if you are still struggling with F.

Class : We are done with F

Teacher : I am not sure about that. Then go for Mg if done with F. Well done that is a Lewis structure for F. Then Mg who is finished with Mg? You need a hint, Mg is in group II, how many valence electrons does it have?

Class : 2

Teacher : Mg has 2 valence electrons. Then draw the 2 valence electrons. Are they paired or unpaired?

Class : Unpaired

Teacher : Show them in your structure the two unpaired electrons of Mg. The teacher then draws the Lewis diagram of Mg (x Mg x). What about He. In which group is He?

Class : Group 18

Teacher : Group 18. How many valence electrons does He have?

Class : 8

Teacher : Haaa……… He?

Class : Yes He has filled orbitals.

Teacher : But how many are those electrons?

Class : 8

Teacher : What is its electron configuration? Let's start from the electron configuration of He.

Class : $1s^2$ $2s^2$

Teacher : Which He are you talking about?

Class : The one in group 18

Teacher : What is its atomic number? Atomic number is?

Class : 2

Teacher : What do we get from the atomic number? What does the atomic number tells us about the atom?

Class : Protons

Teacher : Number of protons is that not so?

Class : Yes

Teacher : And again number of? He is a neutral element.

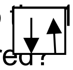
Class : Yes

Teacher : Which means how many protons does it have?

Class : 2

Teacher : Yes that 2 from the atomic number, so how many electrons does He has?

Class : 2

Teacher : Yes 2, then where do you get the 8. He has got 2 electrons. That is why its configuration is $1s^2$. So when you draw the orbital box diagram for He it becomes 1s both electrons goes into  s orbital. So in your Lewis structure do you expect your electrons to be paired or unpaired?

Class : Unpaired.

Teacher : But why the two are paired in the orbital box diagram? He has got a full s orbital. That means the electrons are paired. So in He the electrons are 2 and they are paired because its orbital box or valence shell is full. The reason why Mg has two unpaired electrons? Lets write the electron configuration of Mg. What is it?

Class : $1s^2$

Teacher : How many electrons does Mg has?

Class : 12

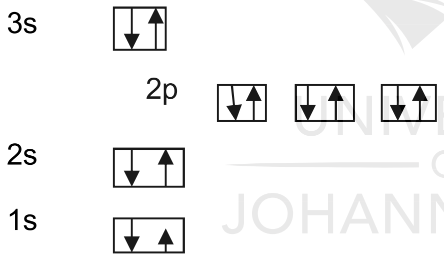
Teacher : Yes 12

Class : $1s^2\ 2s^2\ 2p^6\ 3s^2$

Teacher : Is it full?

Class : Yes

Teacher : If we write the orbital box diagram for Mg it will be:



By the way how many electrons can be fitted into the third energy level?

Class : 6

Teacher : How many electrons can be accommodated in energy level no 3? The total number of electrons.

Class : 6

Teacher : The total number of electrons in energy level no 3

Class : 2, 4, 6.

Teacher : You are guessing people. How many can energy level no3 accommodate?

Learner : 8

Teacher : Yes 8. Is that new? It can be filled by 8 electrons because we have a 3s and a 3p orbital. The 3s takes 2 and the 3p?

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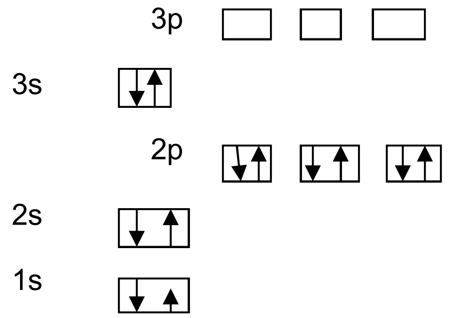
Class : 6

Teacher : Therefore the orbital box diagram for Mg will look like



But energy level 3 for Mg is still missing how many electrons? Which will fill 3p. It still needs 6 electrons for the third energy level to be filled completely. That is why even though the orbital box diagram shows 2 electrons in the 3s paired but the Lewis diagram will show 2 unpaired electrons around Mg because Mg still needs 6 electrons to completely fill the third energy level. Helium has a valency energy level 1 with 2 electrons, which means the whole energy level is completely filled, but for Mg there are still 6 missing electrons for the energy level to be filled. That is the rule you must follow in writing Lewis diagram of atoms. That means from the Periodic Table the only elements with completely filled valence shells are the group 18 noble gases. Because we said they do not take part in chemical reactions. The reason why are they not taking part in chemical reactions is because their valence shells is completely filled with electrons. Let us look at Neon (Ne). In which group is Ne?

Class : 18

Teacher : How many valence electrons does it have?

Class : 10

Teacher : Valence electrons, valence electrons for Ne?

Learner : 8

Teacher : 8, so if you write the electron configuration for Ne it will have 4 pairs of electrons around it. All the electrons are paired so during chemical bonding is there anything for Ne to share? Ne has no electrons to share because the orbitals are completely filled. Its like if you have 50c and your friend has also 50c and you both wants to buy a doughnut which cost R1, will it be possible for you to come together and equally contribute to buy the doughnut?

Class : Yes

Teacher : Yes and it means you will equally be sharing the doughnut. But if you have R1 and your friend has 50c you want to buy a R1 worth doughnut, will there be any reason for you to share?

Class : No

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Teacher : No, because you can buy it on your own, just like Ne and all the other noble gases they do not need to share electrons they have full complements of electrons. So now because we know how to draw Lewis structure of elements we can be able to draw molecules to show that during chemical bonding how are elements arranged. For example if we want to represent H_2O. H_2O is a molecule consisting of two hydrogen atoms and an oxygen. When we talk about chemical bonding we mean the process where elements are going to share electrons. So now O has 6 valence electrons, how many does O needs?

Class : 2 electrons

Teacher : Yes O is in needs of 2 electrons which means any element that can come to donate electrons to O, O will in that way have a full valence shell. Let us look then for O Lewis structure, it has two unpaired electrons that means any element can come and share with the 2 unpaired electrons. That element must bring 2 unpaired electrons and in that way O will end up with 8 valence electrons. Lets look at H, how many valence electrons does H has?

Class : 1

Teacher : How many does H need to have a filled orbital?

Class : 7, 1

Teacher : Its 1, H is in group 1 and has 1 electron and its valence energy level is 1 therefore only need 1 electron. So H can come together with O to share its only electron with the 1 unpaired electron of O. Just like two friends sharing the 50c to buy a R1 doughnut. It is like both friends will now own the R1 doughnut. The doughnut belongs to both friends, because both friends have contributed 50c to the R1. Elements behave the same way. Each element contribute 1 electron but the two electrons (pair) belongs to both atoms. Now if one H comes to share with O and the other H also come to share with the other unpaired electron of O then we will have

Now we can count the number of electrons around oxygen. How many are they?

Class : 8

Teacher : Around O how many are the electrons?

Class : 8

Teacher : They are 8. You cannot fail to do a simple counting up to 8 around O, we have got 8 electrons. Around H how many do we have? Its 2 around each H. So now each element has got a full valence shell. How many electrons are needed by H?

Class : 1

Teacher : 1. How many were needed by O?

Class : 2

Teacher : 2. So now because they have shared electrons both atoms have filled orbitals by sharing. Now we come to the point were we name the sharing of the valence electrons

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that when two atoms come together to share their valence electrons we call that covalent bonding. Covalent bonding is a process whereby two atoms or elements come together to share their valence electrons. What is covalent bonding? Define covalent bonding? I have just given you the definition?

Learner : When two atoms share their atoms.

Teacher : I said its when two atoms come together to share their valence electrons, we call that covalent bonding. For example O is in need of 2 electrons to fill its valence shell. If two atoms will come to share their single valence electrons with O, then O will have a full valence shell and H will have a full valence shell. In that way we have a covalent bond. During the covalent bonding a molecule is formed. That means what is formed out of covalent bonding we call it a molecule. Because H and O has come together to share their valence electrons then what do we call H_2O a molecule. Because we have a H and an O that has to come together to share their valence electrons we call H_2O a molecule. Which is why this is called a water molecule. A molecule will be formed as a result of a covalent bonding. E.g. A oxygen atom has got 6 valence electrons. It needs 2 electrons to fill its valence orbital. So when two atoms of hydrogen atoms come together to share their single valence electrons with oxygen a covalent bond is formed and a water molecule is formed.

Ammonia

What is the molecular formula of ammonia?

Learner : NH3

Teacher : Ammonia is NH3. Can you draw the Lewis structure for NH3, which means you have got how many Hydrogens?

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Class : 3

Teacher : 3 Hydrogens, and how many Nitrogens?

Class : 1

Teacher : And 1 Nitrogen. So if you want to draw the Lewis structure of NH3, normaly we take the element with the greatest number of valence electrons and we put that element at the centre. Then the other elements with less number of valence electrons will surround the element with graeter number of valence electrons. Which means for NH3 we have:

How many electrons does N have?

Learner : 5

Teacher : N has 5 valence electrons. Can you draw the Lewis structure of NH3 now? What will be the product when you have 3 H atoms come together to share their valence electrons with N atom. How are you going to arrange the atoms in a Lewis structure. Draw the Lewis structure for NH3. Ammonia then we have got oxygen gas (O2), hydrogen Cyanide (HCN). Lets start with ammonia, who has got it? (Teacher walks around to check). I want to see the product for ammonia. Its not difficult. What is it? Some of you have got it right, but some are struggling. Go and show on the board.

Learner : A learner goes to the board to write the Lewis structure of ammonia.

Teacher : If you are done with ammonia show how two oxygen atoms bonds to form oxygen gas. How do the two oxygen atoms react during chemical bonding? Look from the examples I have given how I write the electrons around the atom. They are in a particular order. Ok thanks boy for trying go sit down. Some of you have written N for nitrogen then the electrons are flying all over why? The electrons have to be around the element. Correct that please. In ammonia three hydrogen atoms all share their single electrons with the three unpaired electrons of nitrogen.

For oxygen, O has 6 valence electrons, then also do the hydrogen cyanide. Before we draw the one for oxygen, during chemical bonding how many electrons do they share?

Class : 2

Teacher : They share 2 electrons, so when electrons are shared we are going to have a single bond. One bond. Which is formed by 2 electrons. Which means ammonia between the H and N because 2 electrons are shared we will have a bond N-H, this line is called the chemical bond. Again between every H and N there will be a bond

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So for each and every pair of electrons a single bond is created. That means if there are two electrons shared by atoms a single bond is created. For water it will be

How many bonds do we have between one H and O?

Class : 2

Teacher : Where does that 2 comes from? For each and every pair of electrons, a pair is made of how many things? If we talk of a pair of things how many are they?

Class : 1

Teacher : 1

Class : Yes

Teacher : I am saying if you have a pair of electrons, it means you will have 1 bond. A single bond is made of 2 electrons. A pair means 2. A pair of electrons is going to make 1 bond. Lets look again in water between O and H how many electrons are there?

Class : 2

Teacher : 2, so how many bonds will be created there?

Class : 1

Teacher : Yes 1, so between H and O there is 1 bond H-O. again if we look at the other H and O, how many electrons are there?

Class : 2

Teacher : 2. How many bonds should be there?

Class : 1

Teacher : 1. Catch this for every pair of electrons shared a single bond is going to be formed. That means if you have two pairs, how many bonds will you have? If you have 2 pairs, I mean pairs now. A pair means how many?

Class : 2, 1

Teacher : Ok if they say a pair of shoes how many shoes do they mean?

Class : 2 shoes

Teacher : A pair of shoes means 2 shoes. If you have I shoe that means you still need the other shoe its incomplete. Which means in a bond also a single electron cannot form a bond. A bond is formed by 2 electrons, which is a pair. A bond is formed by 2 electrons which is apair, 2 is a pair. Then I am saying if you have got 1 pair a single bond is formed. Which is 1 bond. One pair forms a single bond. Now if you have 2 pairs, how many bonds will be formed?

Class : 4

Teacher : You have 2 pairs now that means you have how many bonds?

Class : 4, 2

Teacher : Ok let's shake hands. If we shake hands (demonstrate by shaking hands with one learner) how many hands do we have here?

Class : Excitedely 2

Teacher : There are 2 hands, that forms a pair. Two hands have created 1 bond. We have 2 hands but they have created 1 bond. A bond has been created by 2 hands, 1 pair. If we shake 2 hands now (shakes both hands with learner), how many pairs do we have now?

Class : 4, 2

Teacher : On each side we have 2 hands forming a pair. How many pairs do we have now? One on the other side how many pairs? A pair is forming a bond how many bonds do we have? How many pairs do we have?

Class : 2

Teacher : How many bonds do we have?

Class : 4, 2

Teacher : If you don't see it now ask others. Oxygen has 6 valence electrons during a chemical bonding the elements arrange themselves in such a way that they allow for the bonding to occur. The elements arrange themselves in order to allow for bonding to occur. You can see that each O has 6 electrons around it and they can only share 2 electrons each. So if they come together to share their 2 electrons they should arrange themselves in such a way that they should allow for the bonding to occur. Its just like shaking hands, if you shake hands with someone you should stand in a way such that shaking hands should be possible. So the same with O, because they want the bonding to occur they should arrange themselves in order to allow that to happen. How then? It means the paired electrons from each O should be placed far from each other. And the unpaired electrons should be such that they can be shared. So the unpaired electrons of each O will be shared with the unpaired electrons of the other O.

So how many bonds are going to be there between the O atoms? How many bonds?

Class : 2, 4.

Teacher : How many bonds?

Class : 2

Teacher : 2 bonds, because we have got how many pairs?

Class : 1

Teacher : (Teacher pointing on the board). This pair is going to create a bond and this pair also is going to create a bond. So there will be 2 bonds between the oxygen atoms.

We call that a chemical bonding which is covalent bonding because they are sharing their valence electrons. Lets count the electrons around each oxygen. Lets count, how many are they? Count the electrons around each O and tell me how many are they? Raise your hand if you have found the answer. Destiny how many are they?

Learner : 8

Teacher : They are 8. Why someone is seeing 8? Any different number from 8? Just count around each O. the 2 O atoms are now equally sharing their electrons. The shared electrons belongs to both O atoms. Therefore around each O there are 8 electrons. Because

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now we have got 2 bonds we call it a double bond. Lets draw the last structure HCN. Let me give you a hint. Put the valence electrons around each element, by doing so you will be able to see which element is in need of the most electrons, that will go to the centre. The element that is in need of the more electrons is the one that goes to the centre. So now if you draw valence electrons for H, C and N you will be able to notice which one is in need of more electrons. Write that down.

CLASSWORK

Draw the diagram for the chlorine gas (Cl2) and methane (CH4).

Consider these electron diagrams.

(see lesson plan appendix I for the diagram)

(a)Draw the Lewis diagram for each element

(b)Give the formula for the molecule

(C)How many electrons surround each O and H

Teacher : I said draw the structure of HCN. You should start by writing the valence electrons for each element H, C and N. The valence electrons will indicate to you how many does each element need. No one gets the HCN correct. How many valence electrons does C have?

Class : 4

Teacher : Has 4. How many does C needs?

Class : 4

Teacher : How many valence electrons does N have?

Class : 5

Teacher : How many does N needs?

Class : 3

Teacher : How many valence electrons does H have?

Class : 1

Teacher : How many does H needs?

Class : 1

Teacher : 1. So it means during chemical bonding how many electrons does C share?

Class : 4

Teacher : C share all 4 electrons. How many does N share?

Class : 4, 2

Teacher : look at the Lewis structure of N, how many does it share? How many electrons does N share? Refer to the Lewis structure.

Learner : 3

Teacher : It shares 3 electrons. C shares 4, N shares 3 and how many does H shares?

Class : 1

Teacher : 1. Now look at how is this going to be possible for the HCN. How HCN is going to be arranged so that C can share all 4 electrons. How many electrons will C share with N? Write down how many electrons will C share with N and how many electrons will C share with H? That is what I want to see. (The teacher walks around checking what learners have written). What is so difficult? How can you fail to arrange these electrons? If you are finished copy the classwork on the board. Lets all look on the board. H has 1 valence electron and C?

Class : 4

Teacher : N has got?

Class : 5

Teacher : Just look how I write the electrons around the elements. I place 4 electrons unpaired first around the element, then start pairing if electrons are still available.

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Then what will be the product? N has 3 unpaired electrons for sharing and C has 4 unpaired electrons for sharing. Which means because N has 3 unpaired electrons for sharing, N will share 3 electrons with 3 unpaired electrons of C.

So between C and N we have 3 electrons from C and 3 electrons from N being shared. Between C and H, H has 1 unpaired electrons for sharing and C is left with 1 unpaired electron to share. So therefore there will be 1 pair of electrons between H and C. Was this difficult? 3 unpaired electrons of C are shared with N and 1 is shared with H.

Copy the classwork and write it at home as homework. Lets us finish here how many bonds will we have between C and N? We will have 1 bond formed by each pair of shared electrons, therefore there will be 3 bonds between C and N which we call triple bond. Write the classwork at home.

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TRANSCRIPT

LESSON OBSERVATION

MS HLOPHE'S LESSON 2

SUBJECT: Physical Sciences

GRADE : 10

TOPIC: Chemical bonding

Teacher : I gave you a homework yesterday and you wrote for compliance. And that is why you got zeros. Just keep quiet there is nothing to celebrate you got zeros. Number 1 you were asked to draw structures for Cl2 and CH4. (The teacher talked strongly to the boys who were seated doing nothing when all the learners were preparing to write the corrections). The Lewis structure of Cl2 and CH4. How do we draw their Lewis structures. The teacher pointed one boy to go and write on the board.

Learner : The learner tried to write on the board but relied much on the support from the class.

Teacher : I told you that for the symbols of elements we use a capital letter for the first letter of the element. For example the symbol for sodium is Na, and would be very wrong to write it as NA. NA is not sodium. And for chlorine the symbol CL is not correct. It should be Cl. And again for chlorine the Cl is one symbol, there can be no sharing of electrons between the C and l, like

C l

The principal came to ask for one boy that cause a little disturbance.

Teacher : The symbol for chlorine is

The 2 Cl atoms are sharing electrons. We first have to write the valence electrons around each Cl. How many are they?

Class : 2

Teacher : I mean the valence electrons.

Class : They are 7

Teacher : You must raise your hand if you know the answer. They are 7. Then they share the unpaired valence electrons. You are marking one mark for showing the 7 electrons and each Cl and the other mark is for showing the sharing of the unpaired electrons.

Then for methane how many valence electrons does carbon (C) have? How many? Majahonke how many valence electrons does C have?

Learner : They are 4

Teacher : How many valence electrons does C have?

Class : Some 4, some 8

Teacher : They are 4

This is your carbon. How many valence electrons does hydrogen (H) has?

Class : It has 1

Teacher : It has 1, so during the electron sharing each H will come with its single electron to share with one of the electrons of C. So after the sharing C will now have 8 electrons, but before it shared electrons it had 4 valence electrons. And then you had a structure.

Draw the Lewis dot diagram for the molecule. How could you draw a Lewis diagram for this molecule? How could you draw a Lewis diagram for this molecule? What is it that is needed for you to draw a Lewis diagram? If you are drawing a Lewis diagram what must it show? H and O and what? What must the H and O be showing in a Lewis diagram? They should be sharing valence electrons, is it not so?

Class : Yes

Teacher : If you look at that diagram does it not show valence electrons around O and H? does it not show?

Class : They have shown them.

Teacher : So what is difficult here? Because you have your 2 O atoms. How many valence electrons belong to each O atom?

Class : 8

Teacher : Before sharing how many valence electrons does each O have?

Class : 4

Teacher : Don't just guess look at your Periodic Table

Class : They are 8, some 6

Teacher : Each O atom has 6 valence electrons. But now we have O and H. which means between O and H they must share a pair of electrons. Which means if you take just 1 O atom alone you have 1 unpaired electron shared with H. the same applies to the other o atom an unpaired electron is going to be shared with a H. how many unpaired electrons will each O have now?

Class : 1

Teacher : Each O has 1 unpaired electron, which means now we have each O sharing an electron pair with a H. what will happen with the unpaired electrons of each of the O atoms? What will happen with the unpaired electrons? Magagula. What will happen? The 2 O atoms will share with each other their unpaired electrons. So now your duty is to arrange your molecule. Now you know that between O and O there is a shared pair of electrons, and between each O and H there is also a shared pair of electrons. So how do I arrange this molecule?

There is nothing difficult in this exercise. If you look carefully from the given question all you needed to do was to remove the circles and leave the electrons around each element. Give the formula for the molecule. What is the formula for the molecule?

Class : H_2O_2

Teacher : We have got 2 H and 2 O. How many electrons surround the O atom?

Class : 8

Teacher : They are 8, 8 electrons. Where will we find a double bond? Are we going to find a double bond in that molecule?

Class : No

Teacher : Why not? Why there is no double bond? How many pairs should form a double bond?

Class : 8

Teacher : A pair form a single bond. So between O and O we have a single bond, and between O and H there is a single pair and a single bond. For there to be a double bond there must be 2 pairs of electrons.

IONIC BONDING

Teacher : Lets talk about ionic bonding. Ionic bonding will occur when a metal react with a non-metal. Ionic bonding is going to occur when a metal react with a non-metal. Give me 1 metal. Any metal from the Periodic Table.

Class : Copper, Zinc, Iron

Teacher : Where do you get all of these metals?

Class : From the Periodic Table

Teacher : Where did we say we find metals in the Periodic Table? Where do we find metals?

Class : Group 1 and group 2 are metals

Teacher : Yes group 1 and group 2 are metals. Look at group 1 and 2 and give me a metal.

Class : Magnesium (Mg)

Teacher : Ionic bonding occur when a metal reacts with a non-metal e.g Na + Cl. All elements on the right hand side of the Periodic Table are non-metals. So when a metal react with a non-metal we get ionic bonding. So because we said when 2 atoms share their valence electrons we call that covalent bonding. Now we have ionic bonding, during the ionic bonding what happens is that the metal is going to donate its valence electrons to the non-metal. The metal will donate its valence electrons to the non-metal. By so doing after the reaction is complete the metal will be left positive and the non-metal is going to be negative.

By the way how many valence electrons are around Na? Valence electrons around Na? The answer is in the Periodic Table.

Class : 1

Teacher : 1. Chlorine (Cl) how many valence electrons are around Cl?

Class : 7

Teacher : 7

What is going to happen during the reaction Na is going to donate the electron for Cl and Cl is going to accept the electron. After the reaction Na loose the electron and becomes positive and Cl gains the electron from Na. so how many electrons will be there around Cl?

Class : 8

Teacher : 8 electrons because Cl has accepted the electron from Na what will be the charge of Cl? Is it -2, -3, -6?

Class : -1

Teacher : It will be -1. The square brackets are used to indicate that now all the electrons belongs to Cl. The charge is for Cl showing that Cl has now gained an electron.

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Let us take Mg reacting with O.

Mg is a metal and O is a non-metal. How many electrons are there around Mg? valence electrons?

Class : 2

Teacher : Don’t shout there are those who still don’t know. And then around O? Yes Manqoba how many are the valence electrons?

Learner : 6

Teacher : They are 6. So during reaction, because Mg is a metal it has got lower ionisation energy. You remember that we talked about it. Because its ionisation energy is low it means it is easy for Mg to donate electrons. O is in need of 2 electrons so instead of them sharing now O will take both of Mg electrons. At the end of the day Mg will be loosing 2 electrons and what will be its charge?

Class : Positive

Teacher : Positive what? 1, 2, 3?

Class : Positive 2

Teacher : 2+, and O how many electrons are around O?

Class : 8

Teacher : O will have 8 electrons accepting the other from Mg and the charge of O?

Class : Negative

Teacher : How many electrons has O gained?

Class : 2

Teacher : So the charge will be negative what?

Class : Negative 2

Teacher : Name it correctly how do we write it here?

Class : 2-

Teacher :

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Then write the reaction for the formation of CaCl2. How is CaCl2 formed? Which one is the metal and which one is a non-metal?

Class : Ca is a metal.

Teacher : Ca is a metal and Cl is a non-metal. Ca will donate and Cl will accept. Then write the reaction when the calcium reacts with 2 chlorine atoms, don't forget that. (The teacher walks around monitoring and checking what the learners were writing). Some learners were found to be without Periodic Table which the teacher supplied. Does anyone gets it? CaCl2. 1 Ca react with 2 Cl atoms. (There were discussions in pairs by learners in their desks). The teacher asked one learner to go and write on the board.

Learner 1 :

Another learner also went to the board to write her version of the reaction

Learner 2 :

Teacher : Is the first one correct. Lets start from the reaction, is it correct? The reaction we check the number of electrons around Ca how many do we have?

Class : 2

Teacher : Around Cl how many do we have?

Class : 7

Teacher : Are they 7 on the board, around each chlorine? How many are they? Remember once your reaction is wrong obviously you will get a wrong product. Because now your Cl has 6 valence electrons, which means Cl needs how many electrons?

Class : 2

Teacher : 2 electrons. Lets check the reaction Ca has 2 electrons reacting with Cl which has 6 electrons. You see that is a mistake. This says already the product will be wrong. The second Cl is correct it has 7 valence electrons. This means in the reaction the first Cl that needs 2 electrons will take both the electrons of Mg and nothing will be left for the second one. Which means your product must show that 2 electrons were taken by the first Cl and nothing was left for the second Cl. It is a mistake that will result to a wrong product. The product is correct each Cl has 8 electrons which is correct, but according to the reaction this was not supposed to be the product. Lets go to the second one.

C a has 2 valence electrons and Cl has 7. Then let's come to the product Ca2+ and how many Cl- are we going to have?

Class : 1

Teacher : She is saying Ca react with Cl, how many electrons does Cl need?

Class : 1

Teacher : But the product shows that Cl has gained how many electrons?

Class : 2

Teacher : Is it possible?

Class : It is not possible

Teacher : Lets write it correctly then.

Each Cl is in need of how many electrons?

Class : 1

Teacher : Which means during the reaction the Ca is going to donate an electron to this one and another electron to the other Cl. So your final product, in your final product how many electrons are there around Ca?

Class : 8

Teacher : Around Ca, how many? Ca has donated.

Class : Yes

Teacher : How many electrons has Ca donated?

Class : 2

Teacher : How many are left?

Class : Nothing

Teacher : Is left with nothing, has lost 2 electrons because it's a metal what is the charge?

Class : 2 positive

Teacher : The charge is 2+. You had indicated you had 2 Cl which were in need of 1 electron each. Which means your product is correct if it is like this

With 2 Cl- or you can just say in your product you had 2Cl-

Is that clear?

Class : Some said yes some no.

Teacher : What is it that you don't see? Write the reaction were magnesium (Mg) reacts with fluorine (F). Use the Lewis diagrams to show the reaction. The problem is that you don't want to relate what we are doing now with what we did earlier. Remember earlier we used to write compounds using cations and anions. It's the same thing, the only difference is that now we are using valence electrons. Mg and F one is going to loose one is going to gain. Lets go back to compounds, if we form compounds. Lets say we want Mg to react with F. What would be the cation of Mg? what is the cation of Mg? it is Mg2+ and F becomes an anion and it is F-, because F gains 1 electron and Mg completely looses its 2 electrons. If we draw the molecular formula for Mg and F what do we get? If we react Mg and F what would be the product? It is MgF2. This is the hint. Use the Lewis structures to draw that product. (The teacher walks around checking while the learners are writing). Someone has got it already. If someone has got it you can find it. For CaCl2 I gave you the product, now I just gave you the reactants, I have just given you the product MgF2. Because Mg will fully loose 2 electrons and F will gain 1 electron, that is why the molecular formula is MgF2. So now draw the Lewis structures to show the ionic bonding. Come David you are finished.

Learner : I am still looking mam.

Teacher : Go and write on the board. Write the reaction for MgF2, which is the ionic bonding were a metal donate for the non-metal.

Learner :

Teacher : Was that difficult? Mg is going to donate for each of the F atoms. At the end you are going to have 2 F atoms that is why the molecular formula is MgF2. You can also write as

In naming the is the same as earlier on. One is a cation and the other is an anion.

Take out your classwork books and write today's date.

CLASSWORK

IONIC BONDING

1. Use Lewis dot diagrams to show the formation of ions and the ionic bond when these reactions occurs
   (a) Lithium reacts with oxygen
   (b) Calcium reacts with chlorine
2. Name the formula and compound of the molecules that will form when :

Lithium metal react with bromine.

Calcium and chlorine gas

Teacher : Go and write this at home and please write at home.

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29 OCTOBER 2014

TOPIC: EQUATIONS OF MOTION

CONCEPTS: displacement, distance, speed, velocity

SKILLS: writting, Listening, problem-solving skills

DURATION: 45 min

CONTENT: The kinematics equations to solve problems involving motion in one dimension (horizontal) only

Equation 1 $v_f = v_i + a\Delta t$

Equation 3 $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$

Equation 2 $v_f^2 = v_i^2 + 2a\Delta x$

Equation 4 $\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$

v_f = final velocity ($m.s^{-1}$)

v_i = initial velocity ($m.s^{-1}$)

a = acceleration ($m.s^{-2}$)

Δt = time in (s) time taken in (s)

Δx = displacement in (m)

Steps to follow to solve equations of motion

1. Write down given quantities and the quantities you need to calculate
3. Choose one direction as positive and the opposite direction will then be chosen as negative
2. Identify the equation to solve a problem
4. Substitute the values into the equation
5. Calculate the unknown quantity.

Example 1: An aircraft accelerates from rest at $8 m.s^{-2}$ down a runway. Calculate how fast it will be travelling after 40s

$v_i = 0\ m.s^{-1}$ $\quad v_f = v_i + a\Delta t$

$a = 8\ m.s^{-2}$ $\quad v_f = 0 + 8(40)$

$\Delta t = 40s$ $\quad v_f = 0 + 320$

$v_f = ?$ $\quad v_f = 320\ m.s^{-1}$

$v_f = 320\ m.s^{-1}$, in the direction of motion (forward direction)

Example 2: A car is travelling along the road at $8\ m.s^{-1}$. It accelerates at $2\ m.s^{-2}$ for 3s. Calculate the displacement while accelerating

Example3: $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$v_i = 8m.s^{-1}$ $\quad = 8(3) + \frac{1}{2}(2)(3)^2$

$a = 2m.s^{-2}$ $\quad = 24m + 9m$

$\Delta t = 3s$ $\quad \Delta x = 33m$

$\Delta x = ?$ $\quad \Delta x = 33m$ in the direction of motion.

Example3: A minibus is travelling at $15\ m.s^{-1}$. When a robot 30m away changes to orange, the driver breaks hard to stop in time. Calculate his acceleration

$v_i = 15\ m.s^{-1}$

$v_f = 0\ m.s^{-1}$

$\Delta x = 30m$

$a = ?$

$v_f^2 = v_i^2 + 2a\Delta x$

$(0)^2 = (15)^2 + 2(a)(30)$

$a = -3{,}75\ m.s^{-2}$

$a = 3{,}75\ m.s^{-2}$, opposite to the direction of motion.

ASSESSMENT:

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GR 10 — 30 OCTOBER 2013

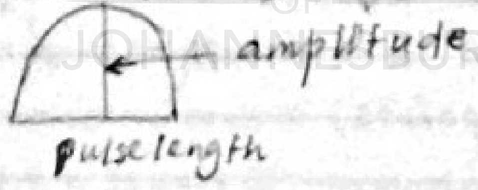
TOPIC: WAVES, SOUND AND LIGHT

CONCEPTS: VIBRATIONS, PULSES, WAVES, TRANSVERSE WAVES, AMPLITUDE, SUPERPOSITION WAVELENGTH, FREQUENCY, PERIOD AND WAVE SPEED, EQUILIBRIUM POSITION, LONGITUDINAL WAVES

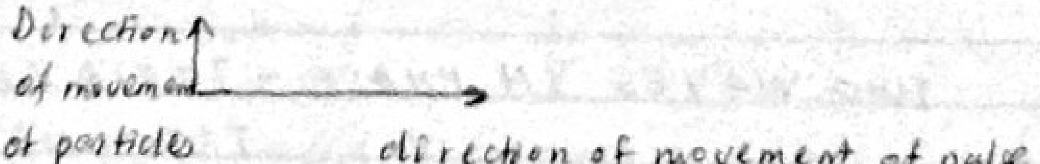
SKILLS: WRITTING, LISTENING, CALCULATING

CONTENT: TWO TYPES OF WAVES

- TRANSVERSE AND LONGITUDINAL WAVES
- THESE WAVES ARE THE MECHANICAL WAVES RESPONSIBLE FOR WAVES IN WATER & SOUND
- NEED TO UNDERSTAND THE PROPERTIES OF WAVES TO BE ABLE TO USE THEM.
- PULSE - SINGLE DISTURBANCE IN A MEDIUM
- AMPLITUDE - MAXIMUM DISPLACEMENT OR DISTURBANCE OF A PARTICLE FROM THE REST POSITION (EQUILIBRIUM POSITION)



HOW A TRANSVERSE PULE IS GENERATED?
PARTICLES MOVE AT RIGHT ANGLES TO THE FORWARD DIRECTION OF THE PULSE.



SUPERPOSITION OF PULSES - OCCUR WHEN TWO PULSES MEET TO OCCUPY THE SAME SPACE AT THE SAME TIME
OR THE ADDITION OF THE DISTURBANCES OF THE TWO PULSES THAT OCCUPY THE SAME SPACE AT THE SAME TIME

THE PULSE COMBINE AND THE RESULTANT DISPLACEMENT IS THE SUM OF THE DISPLACEMENTS OF THE ...

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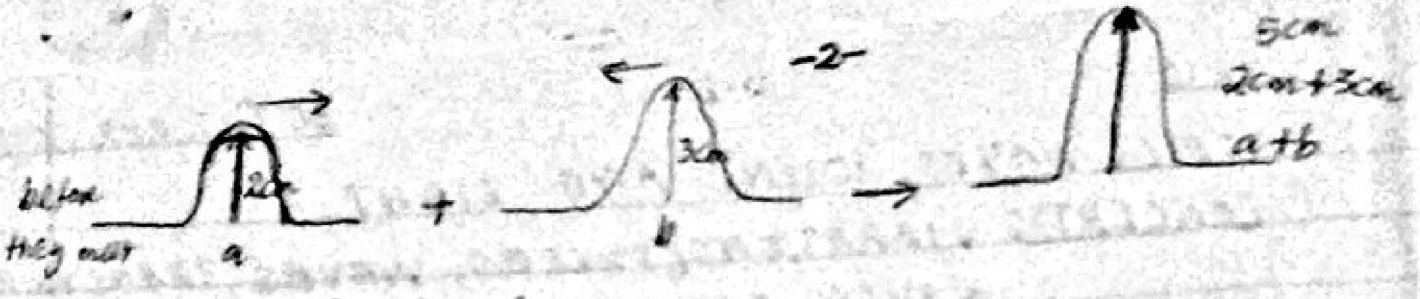
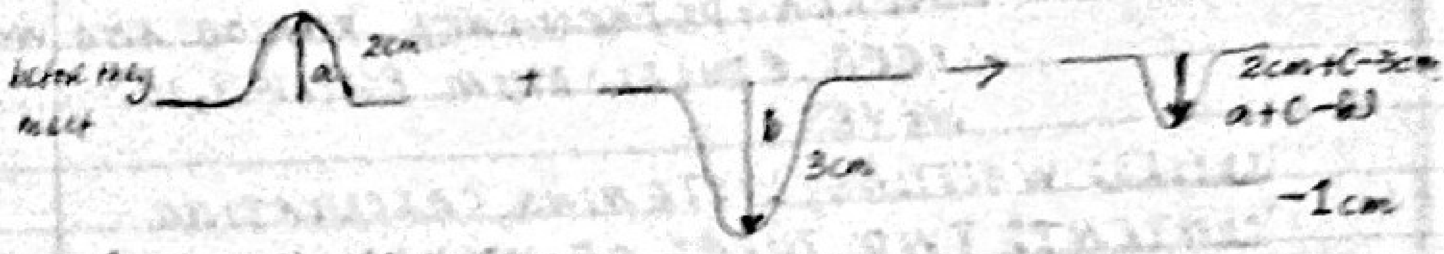


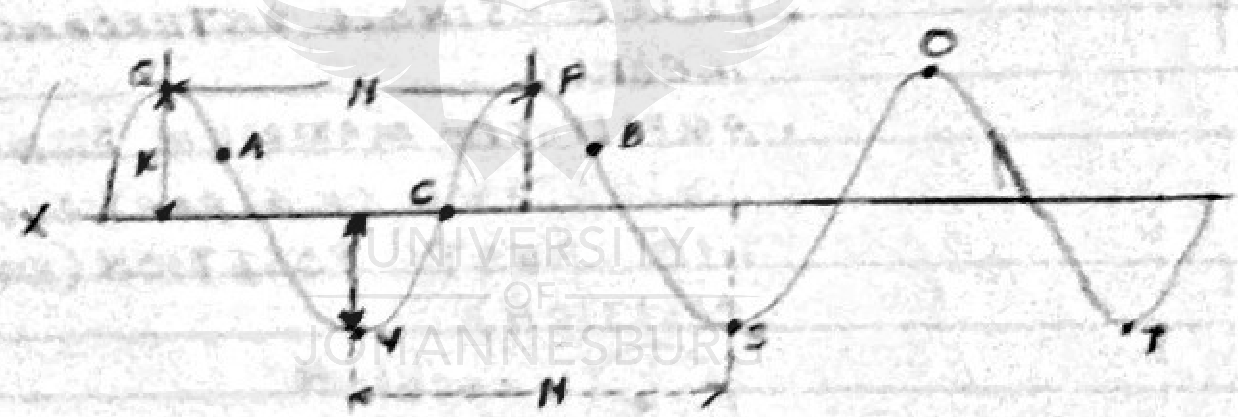
Construction Interference



Destruction interference

ASSESSMENT: STUDY AND MASTER Pg.105 Activity 2
MEMO Ref. EDUCATOR'S GUIDE STUDY & MASTER

TRANSVERSE WAVES - IS A SUCCESSION OF TRANSVERSE PULSES.



Label the points
- XY
- Q, P AND O
- V, S AND T
- H

TWO WAVES IN PHASE - THEIR CRESTS AND TROUGHS ARE IN LINE
✓ OR MAKE SAME MOVEMENT AT THE SAME TIME
e.g. Q and P, P and O
V and S, S and T

OUT OF PHASE

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Period (T) - TIME TAKEN TO COMPLETE ONE FULL VIBRATION

MEASURED IN SECONDS (S)

FREQUENCY (f) - NUMBER OF VIBRATIONS IN 1 SECOND

MEASURED IN HERTZ (Hz)

e.g. If a pendulum completes two full vibrations cycles in 1 second, its frequency will be 2 Hz. The time taken for one full vibration cycle will be half a second. therefore the period is 0,5s

RELATIONSHIP BETWEEN FREQUENCY AND PERIOD

- $f = \frac{1}{T}$ OR $T = \frac{1}{f}$

$$\text{Wave speed} = \frac{\text{distance (in m)}}{\text{time (in s)}}$$

$$v = \frac{\Delta x}{\Delta t}$$

The wave travels a distance of one wavelength (λ) in a time equal to one period (T) so:

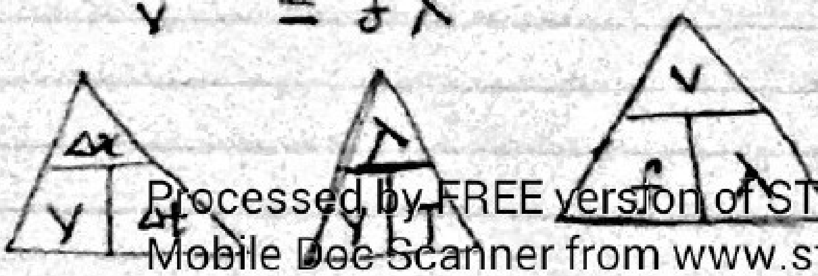
$$\text{wave speed} = \frac{\text{wavelength (in m)}}{\text{period (in S)}}$$

$$v = \frac{\lambda}{T}$$

$$\text{but } f = \frac{1}{T}$$

wave speed = frequency (in Hz) x wavelength (in m)

$$v = f\lambda$$



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Do example 1 and 2 page 109

The statement ; if a crest moves past a given point every second

SAME AS: ONE WAVE MOVES PAST A GIVEN POINT IN ONE SECOND

ASSESSMENT:

1. Define the following terms:
   a) wavelength
   b) frequency
   c) period
   d) amplitude

Do activity 1 pg. 110 No. 1 and 2.

DURATION: 1H00

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04-03-2015

CHEMICAL BONDING

LEWIS DOT DIAGRAM

A lewis dot diagram is a diagram that shows an element and its valence electrons. Each element has got its own valence electrons. So for each valence electrons we use the dots to indicate the electrons.

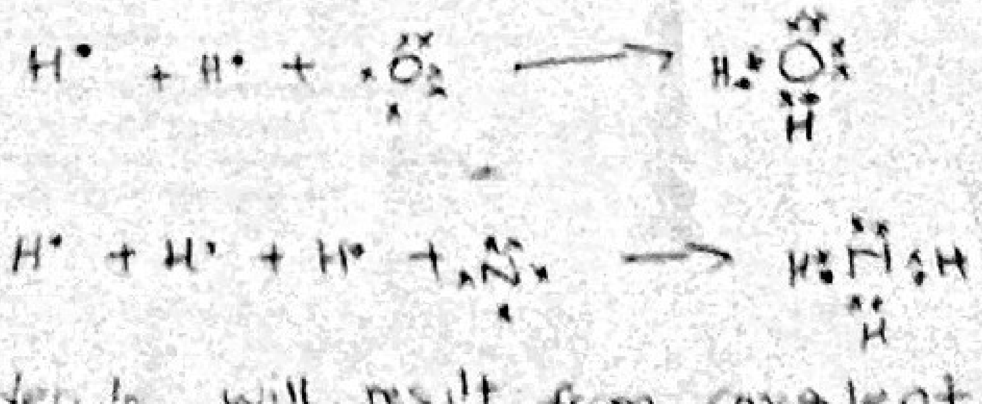
e.g

·Li He: ·Mg· ·N· ·O:

Covalent Bonding

During a chemical bonding elements use their valence electrons to bond. They may come together to share their valence electrons and that is called covalent bonding. For example oxygen has got 6 valence electrons and is in need of 2 electrons. So if any two hydrogen atoms can come to share their valence electrons with oxygen then oxygen will have a full valence shell, and so does the hydrogen

e.g



A molecule will result from covalent bonding.

When a single pair of electrons is shared we call it a si[illegible]

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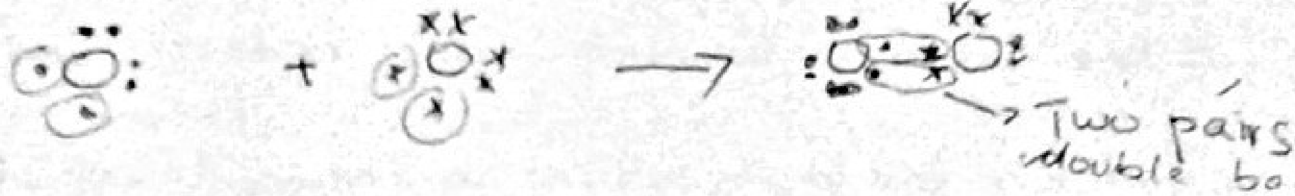
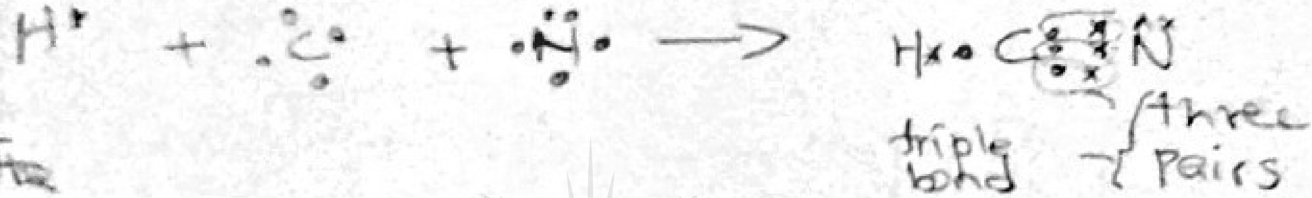
two pairs - double bond
three pairs - Triple bond.

We say that during a Chemical bond elements arrange themselves in order to allow for the sharing to occur.





~~The~~

The element in need of most electrons is written at the Centre for best bonding | arrangement.

Classwork

Textbook pg 92.

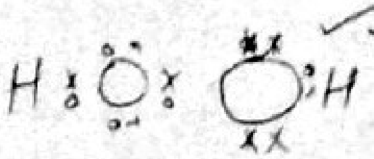
Draw the Lewis dot diagrams of chlorine gas and methane (CH_4).
Consider these electron diagrams.

Hydrogen peroxide   Ethyne

a) Draw the Lewis dot diagrams for the molecules.
b) Give the formulae of the molecules.
c) How many electrons surround each C and O atom?
d) Where would you find a double bond?

Memo

a)



b) H_2O_2 ✓

c) $8e^-$ ✓

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Ionic Bonding

In an ionic bond electrons are transfered from one atom to another.

- The metal ~~for~~ donates the electrons to the non-metal.
- These reaction occurs between a metal and a non-metal.
- The metal forms a positive ion and the non metal forms a negative ion.

e.g. $Mg + O \rightarrow Mg^{2+} [O]^{2-}$

$Cl + Ca + Cl \rightarrow Ca^{2+} 2[Cl]^{-}$

$Na + Cl \rightarrow Na^{+} [Cl]^{-}$

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Classwork

1 Use Lewis dot diagrams to show the formation of ions and the ionic bond when these reactions occur:

a) magnesium reacts with fluorine

b) lithium reacts with oxygen.

2 Name and give the formulae of the ionic compounds that will form when

a) lithium metal reacts with bromine fumes

b) calcium metal reacts with chlorine gas

c) sodium burns in oxygen.

memo

1. $Mg + F + F \rightarrow Mg^{2+} [F]^{-}$ ✓

a. $Li + Li + O \rightarrow 2Li^{+} [O]^{2-}$ ✓

2.

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2(a) Lithium bromide $LiBr$ ✓
(b) Calcium Chloride $CaCl_2$ ✓
(c) Sodium Oxide NO_2 ✓

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Grade 10
Physical Science
Date: 04/03/2015
Topic: Newton's Law of Universal Gravitation
Duration Time: 1 hour.
Resources: Textbook.
Content:
1. State Newton's Law of Universal Gravitation
2. Calculation of the force exerted between two objects.
3. Making r the subject of the formula.
4. Conversion of units.

Newton's Law of Universal Gravitation states that every particle in the Universe attracts other particles with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

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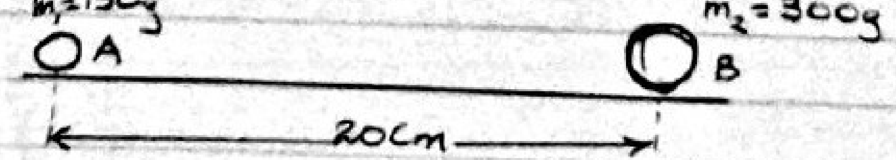
$F = \frac{G m_1 m_2}{r^2}$

G is the gravitational const.
$\therefore G = 6,7 \times 10^{-11} N \cdot m^2 \cdot kg^{-2}$.
m_1 and m_2 are the masses in kg.
r is the distance between the centres in m.

Two balls are lying on the playground as shown. Ball A has a mass of 150g and ball B has a mass of 300g.



1. Calculate the gravitational force that ball A exerts on ball B.
2. Calculate the gravitational force that ball B exerts on ball A.

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3. Calculate the gravitational force that the earth exerts on each ball.

Answers:

$F = \frac{G m_A m_B}{r^2}$

$m_A = 150g$ $\therefore m_A = \frac{150}{1000} kg = 0,15 kg$

$m_B = 300g$ $\therefore m_B = \frac{300}{1000} kg = 0,3 kg$

$r = 20cm$ $\therefore r = \frac{20}{100} m = 0,2 m$

① $F = \frac{G m_A m_B}{r^2} = \frac{(6,7 \times 10^{-11})(0,15)(0,3)}{(0,2m)^2}$

$= 7,5375 \times 10^{-11} N.$

② The force exerted by B on A has the same magnitude as the force exerted by A on B, that is $7,5375 \times 10^{-11} N$. But points in the opposite direction.

③ For A: $F_g = mg$
$= (0,150kg)(9.8m/s^2)$
$= 1,47N$ downwards

For B: $F_g = mg$
$= (0,300kg)(9,8m/s^2)$
$= 2.94N$ downwards.

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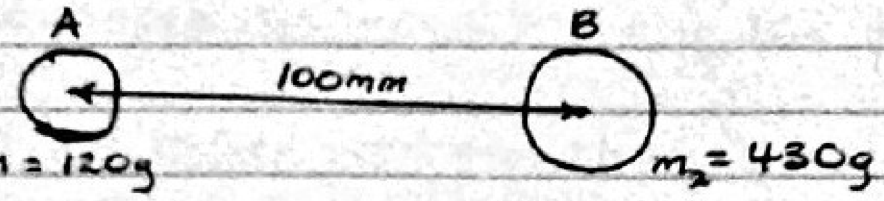
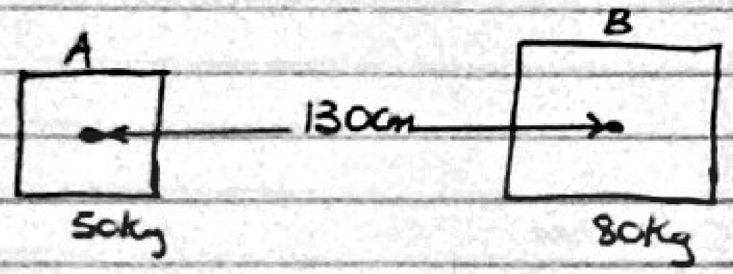
WORKSHEET 04/03/2015

1. Use the given data to calculate the magnitude of the force in each situation below:

(a)



(b)



1.(a)

[5]

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1.(b)

[3]

2. The gravitational force of attraction between two mass pieces of 16kg and 40kg respectively is $2{,}68 \times 10^{-8}$ N. Calculate the distance between their centres.

[5]

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Grade 10 Date: 05-03-2015

Topic: Geometrical optics.

Duration Time: 1 hour.

Resource: Textbook

Content: 1. Reflection of Light.

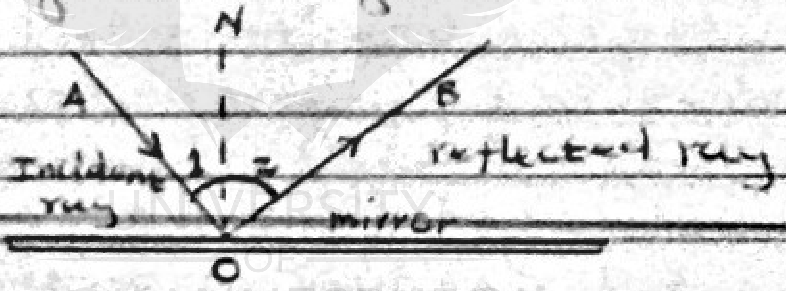
2. Refraction of Light.

Reflection of Light

- It occurs when light strikes a boundary surface through which it cannot pass and moves back into the same medium

* Optical medium.

Any medium through which light can be propagated that is, through which light can move.



* A ray falling onto a mirror, ray AO, is called the incident ray.
* The point O is called the point of incidence.
* The light ray reflected by the mirror, OB, is called the reflected ray.
* We always draw this line, NO, at right angles to the reflecting surface at the point of incidence. It is called a Normal.
* The angle between the incident ray and the Normal ∠1 is called the angle of incidence.
* The angle between the reflected ray and the Normal (∠2) is called the angle of reflection.

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* The Law of Reflection states:
when light is reflected, the angle of incidence is always equal to the angle of reflection.

Refraction of light.

* Refracting light: the bending of light when it passes from one optical medium to another that has a different optical density.
* Caused by a change in the speed of light at the boundary between the two media.
* Light travels at different speeds in different optical media.
- Light travels faster in Air than in glass.
- Glass has a higher optical density than air.
- The higher the optical density of a material, the slower the speed of light in that material.
- Refraction of light is caused by a change in the speed of light at the boundary between the two different optical media.
- The bigger the difference in the speed of light in the two materials, the more the light will bend at the boundary.

* Light has a maximum speed in a Vacuum.
* A Vacuum is a space where there are no air molecules and therefore no air pressure.
* We can regard outer space as a Vacuum.
* $c = 3 \times 10^8$ m/s (speed of light).
* Speed of light in water is $\frac{3}{4}c$
* The speed of light stays constant while it travels within a particular optical medium.
* The speed changes only at the boundary between two different media.

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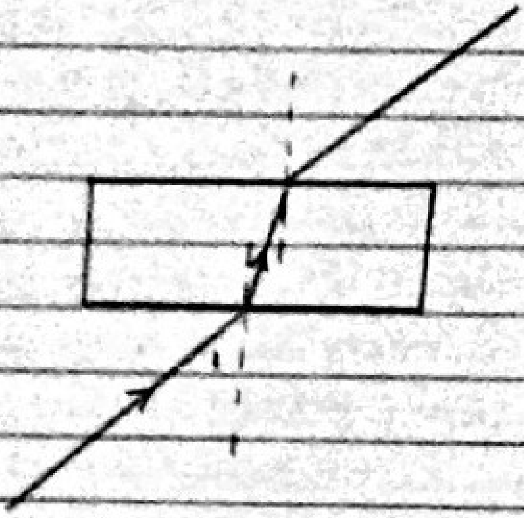
Refraction of light through a Rectangular glass block.



* A normal is a reference line drawn perpendicularly to the surface of a boundary separating two media at the point of incidence.
* AB is the incident ray.
* ∠1 is the angle of incidence.
  It is the angle between the incident ray and the Normal.
* BC is the refracted ray.
* ∠2 is the angle of refraction.
  It is the angle between the refracted ray and the Normal.
* CD is the emergent ray.
* ∠3 is the angle of incidence for the ray that moves from glass to air.
  In the same way, ∠4 is the angle of refraction for the ray that moves from glass to air.
* Rays AB and CD are parallel.

$\therefore \angle 1 = \angle 4$

$\angle 2 = \angle 3$

These angles are equal because the [illegible] surfaces where refraction takes [illegible]

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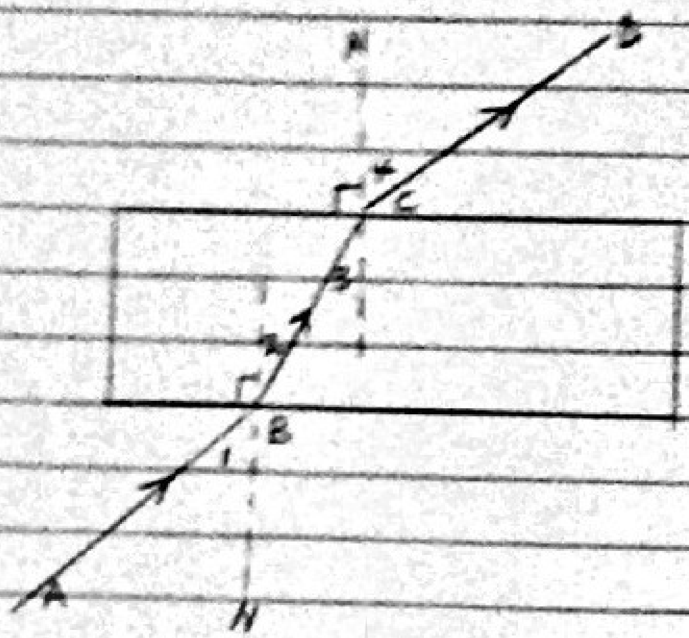

* ∠2 Smaller than ∠1.
* Light ray is bent away from the Normal when it moves from glass to air. (From more to less dense medium).
* ∠4 is larger than ∠3.

* Light that passes into an optically denser medium is refracted towards the Normal.
* Light that passes into an optically less dense medium is refracted away from the Normal.

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* The ratio of speed of light in a vacuum to the speed of light in another optical medium material, V, is called the refractive index, n

$\therefore n = \frac{c}{v}$

* A bigger value of n indicates that the speed of light in a material is slower.

∴ light bends more when it passes from air into that material.

* The higher the optical density of a material, the bigger the refractive index of that material.

Material	Refractive Index
Air	1,00
Water	1,33
Ethanol	1,36
Paraffin	1,44
Perspex	1,49
Glass	1,52.
Diamond	2,42.

When refraction takes place, the speed of the light wave changes, but its frequency stays the same.

* Refraction is therefore a change of the speed of a light wave in different media while the frequency remains constant.

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Appendix J: Transcribed interviews

INTERVIEWS WITH GRADE 10 PHYSICAL SCIENCES TEACHERS

QUESTION	MA	NE	HL	THEMES
The current Physical Sciences statement prescribes the use of scientific inquiry in the teaching of Physical Sciences. What do you understand by that?	I think the people who drafted this policy do not understand what is happening on the ground. We have no laboratories, no equipment and the classes are overcrowded how can we conduct experiments all the time.	Inquiry needs time and on the other hand one has to complete the schedule and be at par with the pace setter. It is difficult to find time to conduct investigations.	Sometimes I try to engage these learners on experiments before we discuss a concept but these learners do not have the required skills. I end up doing everything myself. Some of these learners they just don't care.	• No laboratories • Overcrowded classes • Time allocated in the curriculum not enough • Curriculum to be completed • Lack of skills by learners • Learners demotivated
How does the instructional method you have chosen support development	These learners do not have textbooks or any other source of	This method is effective because it allows me to finish the schedule on	Taking these learners slowly through the content and	• No learning materials • Passing of standard tests

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of content understanding ?	information. So it's best I give them everything and they write notes so that they will something to study.	time so that these learners won't fail the tests or examinations.	giving them notes is the only best method I can use to help these learners.	• Slow learners
How does your instruction support development of thinking?	If they have something to read, then their thinking can be improved, I also give them a lot of written exercises.	With all the notes I give them and the training I give them, they normally do well in tests and examination.	These learners are struggling it is therefore better that I give them some hope by giving them notes and asking them easy questions. I also assist them a lot.	• Reading and written work for learners • Passing of standard tests • Motivation by easy questions
Besides the understanding of content and thinking skills, what else guides your selection of	The availability of resources including time and the number of	The need to cover certain amount of work within a particular time and the performance of learners in	The ability of these learners to cope with the volume of work we have to do. To me that	• Availability of teaching resources • Availability of time • The number of learners in classes

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instructional approaches?	the learners in my class.	tests. That is important because if learners do not perform because you did not finish the work then you are in trouble.	is the most important thing.	• Work to be covered • Performance of the learners in standard tests • Ability to cope by learners
What impact does the CPD programs have on your instructional design and practice	All these programs speak of ideal situations and we are facing something else here.	They are very good unfortunately some of the strategies are not applicable in our school. The time allocated is just not enough for some of the things.	They are very helpful in some areas like making one aware of the sections to be covered, and to be aware of what is needed for moderations at the end of the year.	• Programmes do not address current situations • Strategies are not applicable • No enough time • Very helpful in some areas

Appendix K: Consent form for teacher

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Informed Consent/Assent Form

Project Title:
Investigating grade 10 Physical Sciences teacher's beliefs and attitudes about inquiry-based teaching and learning.

Investigator:
Manzini Samson Hlatshwayo

Date:
17 June 2014

Please mark the appropriate checkboxes. I hereby:

☐ Agree to be involved in the above research project as a participant.
☐ Agree to be involved in the above research project as an observer to protect the rights of:
 ☐ Children younger than 18 years of age;
 ☐ Children younger than 18 years of age that might be vulnerable*; and/or
 ☐ Children younger than 18 years of age who are part of a child-headed family.
☐ Agree that my child, ____________________ may participate in the above research project.
☐ Agree that my staff may be involved in the above research project as participants.

☐ I have read the research information sheet pertaining to this research project (or had it explained to me) and I understand the nature of the research and my role in it. I have had the opportunity to ask questions about my involvement in this study. I understand that my personal details (and any identifying data) will be kept strictly confidential. I understand that I may withdraw my consent and participation in this study at any time with no penalty.

☐ Please allow me to review the report prior to publication. I supply my details below for this purpose:
☐ Please allow me to review the report after publication. I supply my details below for this purpose:
☐ I would like to retain a copy of this signed document as proof of the contractual agreement between myself and the researcher

Name: ____________________

Phone or Cell number: ____________________

e-mail address: ____________________

Signature: ____________________

If applicable:
☐ I willingly provide my consent/assent for using audio recording of my/the participant's contributions.
☐ I willingly provide my consent/assent for using video recording of my/the participant's contributions.
☐ I willingly provide my consent/assent for the use of photographs in this study.

Signature (and date): ____________________

Signature of person taking the consent (and date): ____________________