Outcomes-based assessment of Physical Sciences in the FET band

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OPSOMMING

Sedert die aanvang van Uitkomsgebaseerde Onderwys (UGO) in Suid-Afrika, het onderwysers veral ten opsigte van die implementering van Uitkomsgebaseerde Assessering (UGA), baie verwarring en frustrasie beleef, Onderwysers is vanaf die begin van die implementering van UGO in Suid-Afrika gekonfronteer met onbekende uitdagings ten opsigte van onderrig, leer en assessering. Baie van hierdie onderwysers het hierdie uitdagings as stresvol beleef, omdat hulle ontoereikend voorberei was vir hierdie paradigma skuif. Dit het aanleiding gegee tot 'n algemene gevoel van negatiwiteit en weerstand teenoor UGO by onderwysers. In die besonder, het dit geblyk asof daar baie verwarring en frustrasie by onderwysers bestaan het oor die werklading en administratiewe las wat UGA op onderwysers geplaas het.

Teen die agtergrond van die voorafgaande, wou die navorser vasstel hoe onderwysers in die Noordwes-Provinsie die UGA van Fisiese Wetenskappe in die Verdere Onderwys en Opleiding (VOO) Band ervaar.

Ten einde die navorsingsdoel en -doelwitte te bereik, is 'n literatuurstudie en 'n empiriese ondersoek onderneem. In die lireratuurstudie is daar gefokus op UGA, UGO, en die Nasionale Beleidsdokument oor die onderrig, leer en assessering van Fisiese Wetenskappe in die VOO Band

Vir die doeleindes van die empiriese ondersoek is kwantitatiewe en kwalitatiewe data deur middel van 'n vraelys ingesamel wat onder 'n steekproef van onderwysers versprei is wat Fisiese Wetenskappe in die VOO Band in skole in die Noordwes-Provinsie onderrig het. Die data is kwantitatief en kwalitatief geanaliseer en op grond van die bevindinge, is die volgende gevolgtrekkings gemaak:

- Alhoewel die meeste van die deelnemers aangedui het dat hulle opleiding in UGA ontvang het en in besit van die relevante Nasionale Kurrikulumverklaring (NKV) dokumentasie was, het sommige van die deelnemers se response aangedui dat hulle praktiese implementeringsvaardighede ontoereikend was. Dit het ook geblyk dat sommige deelnemers 'n tekort aan bronne en ondersteuning van vakadviseurs oor die implementering van UGA ervaar het.

- Deelnemers het die volgende struikelblokke ervaar met betrekking tot die assessering van Fisiese Wetenskappe in die VOO Band:
  - ontoereikende opleiding om praktiese werk uit te voer;
  - 'n gekompliseerde en verwarrende NKV dokument wat nie duidelike riglyne bevat nie, en
  - beperkte bronne, tydsbeperkinge, oorvol klasse en 'n oorbelaaide kurrikulum maak dit baie moeilik om praktiese werk en eksperimente te doen.

Op grond van die bevindinge wat uit die navorsing voortgespruit het, is ŉ model vir die implementering van UGA vir Fisiese Wetenskappe in die VOO Band voorgestel ten einde die gaping tussen assesseringsteorie en -praktyk te oorbrug.

Sleutelwoorde: *Uitkomsgebaseerde Onderwys, Uitkomsgebaseerde Assessering, Assessering van Fisiese Wetenskappe in die VOO Band*.

ABSTRACT

Since its inception, the Outcomes-Based Education (OBE) curriculum in South Africa has caused much confusion and frustration among teachers, especially with regard to the implementation of Outcomes-Based Assessment (OBA). From the onset of the implementation of OBE in South Africa, teachers were confronted with unfamiliar challenges with regard to teaching, learning and assessment. Most teachers experienced these challenges as very stressful, because they were inadequately prepared for the didactical paradigm shift. This resulted in a general degree of negativity and resistance towards OBE amongst teachers. In particular, there seemed to be much confusion and frustration about the workload and administrative burden that OBA imposed on teachers.

In the light of the afore-mentioned, the researcher wished to determine how the teachers from the North-West Province experience the OBA of Physical Sciences in the Further Education and Training (FET) Band.

In order to achieve the aim and objectives of the research, a literature study as well as an empirical investigation was undertaken. The literature study focused on OBA, OBE, and the National Policy Document on the teaching, learning and assessment of Physical Sciences in the FET Band.

For the purposes of the empirical investigation, quantitative and qualitative data were collected by means of a questionnaire that was distributed among a sample of teachers who taught Physical Sciences in the FET Band schools in the North-West Province. The data were quantitatively and qualitatively analyzed and on the basis of the findings the following conclusions were drawn:

- Although most participants indicated that they received training in OBA and were in possession of the relevant National Curriculum Statement (NCS) documents, some of their responses indicated a lack of practical implementation skills. It also transpired that some of the participants experienced a lack of resources and inadequate support from subject advisors in implementing OBA.
- Participants experienced the following obstacles with regard to the assessment of Physical Sciences in the FET Band:
    - inadequate training to conduct practical work;
    - a complicated and confusing NCS document that does not contain clear guidelines;
    - an overloaded curriculum; and
    - limited resources, time constraints, overcrowded classrooms and an overloaded curriculum make practical work and experimentation very difficult.

On the basis of the findings emanating from the research, a model for the implementation of OBA of Physical Sciences in the FET Band was proposed to close the gap between the theory and assessment practice.

Key words: *Outcomes-Based Education, Outcomes-Based Assessment, Assessment of Physical Sciences in the FET Band.*

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CHECKING OF BIBLIOGRAPHY

Hereby I declare that I have checked the technical correctness of the Bibliography of the PhD.-thesis of Mr N Morabe according to the prescribed format of the Senate of the North-West University.

Yours sincerely

Prof CJH LESSING

CHAPTER 1

ORIENTATION AND PROBLEM STATEMENT

1.1 Introduction

In 1994 the new South African government faced a series of mammoth tasks and set itself a series of difficult priorities. The crucial one was to redress the inequalities of the chequered past. The most immediate problem the government had to face was a bureaucratic, administrative and informational one that had to do with creating a single educational department from the previous 19 departments of education within the frame of nine provinces (Gilmour, 2001:6). The new South African government then embarked on an urgent programme of restructuring its education system on principles of equity, human rights, democracy and sustainable development. Changes have included among others a unified, national education system, a more democratic system of school Governance, a new standards and qualifications authority, redistribution of financial and human resources, higher education reforms and the re-orientation to Outcomes-Based Education. Yet, against this backdrop of change, the South African education system still faces major challenges.

Curriculum 2005 (C2005) was introduced in order to enable the country to move away from a racist, Apartheid, rote-learning model of learning and teaching to a liberating, nation-building and learner-centred Outcomes-Based Education (DoE, 2001a:5). According to Howie (2002:42) (quoting DoE, 1996), the vision of the government was:

> *To create a South Africa in which all people have equal access to lifelong education and training opportunities which will contribute towards improving the quality of life and build a peaceful, prosperous and democratic society.*

Curriculum 2005 had to function as transformational tool aimed at equipping all learners with the necessary skills, values and attitudes to take up their rightful place in society as individuals who could think creatively, critically and independently.

Curriculum 2005 aimed at allowing greater mobility between different levels of education and institutional sites, and to integrate knowledge and skills through “learning pathways”. Curriculum 2005’s assessment, qualifications, competency, and skills-based framework sought to encourage the development of curriculum models attuned to the National Qualification Framework (NQF) in theory and practice (Howie, 2002:42).

Although Outcomes-Based Education (OBE) was already controversial abroad, it proved to be even more controversial in South Africa. Many school principals and teachers who were interviewed by different researchers, amongst others Pretorius (1998), expressed their doubts regarding OBE. Numerous parents were also worried that standards would drop. Certain critics believed that OBE did not work in leading industrial countries such as the USA, Canada, Australia and New Zealand and many of these countries already started moving back to a traditional education approach (Pretorius, 1998:iii).

According to the research report of some thirty five research studies spanning a variety of subject areas and types of schools in South Africa, most teachers in schools have not been adequately trained in the use of Outcomes-Based teaching approaches and would need retraining to be able to teach within this system (Taylor, 1999:106). Taylor (1999) and Onwu & Mugari (2004) described that what was happening in many OBE classrooms did not appear to be that different from the pre-OBE norm. They found it to be characterised by the following features (Taylor, 1999:107 and Onwu & Mugari, 2004:162):

- The lessons were dominated by teacher talk and low-level questions.
- Lessons were generally characterised by a lack of structure and the absence of activities that promote higher order skills such as investigations, understanding relationships and curiosity.
- Real world examples were often used, but at a very superficial level.
- Little group work or other interaction occurred between learners.

During the implementation process, Rogan (1999) (as quoted by Onwu & Mugari, 2004:162) stated that most schools have many teachers who have little experience, meagre training, and who operate in under-resourced, large classes with learners who speak a variety of home languages. Despite these constraints, they are expected to implement a very sophisticated curriculum, the aim of which is to shift the focus from memorising content and regurgitating it in tests and examinations, to what learners could do with their knowledge, and in particular whether they could use what they know to meet the specified outcomes (Hattingh et al., 2005:13).

According to Hattingh et al., (2005:13), Curriculum 2005 made the following claims:

- The move towards an Outcomes-Based approach was due to growing concern around the effectiveness of traditional methods of teaching and training, which are content based.
- An Outcomes-Based approach to teaching and learning, however, differs quite drastically from the pre-OBE approach and presents a paradigm shift. According to Spady (1994), outcomes are high-quality, culminating demonstrations of significant learning in context.

- An Outcomes-Based Education and Training system requires a shift from focusing on teacher input (instructional offerings or syllabuses expressed in terms of content) to focusing on outcomes of the learning process.
- Outcomes-Based learning focuses the achievement in terms of clearly defined outcomes, rather than teacher input in terms of syllabus content.
- In Outcomes-Based learning, the learner's progress is measured against agreed criteria. This (Hattingh, et al., 2005:13) implies that formal assessment would employ criterion-referencing and would be conducted in a transparent manner.

After its implementation in the General Education and Training (GET) band in 1998, it was clear that the curriculum was not properly researched. In 2000, the inherent flaws in the curriculum were becoming obvious and teachers did not know what to teach. Studies conducted locally revealed a need to revisit the new curriculum. The new curriculum for South African schools was a watershed: its Outcomes-Based Education approach represented a new paradigm in education. Although Curriculum 2005 claimed to have been developed through an extensive process of participation and consultation, it was attacked from many quarters (Jansen, 1998 and NAPTOSA, 2004, among others) primarily because of the anticipated difficulty of implementing it in a system with so many under-prepared and under-qualified teachers (Howie, 2002:44).

Jansen (1998:321) and De Clercq (1997:133) called it an example of idealistic reaction to Apartheid education which had little to do with everyday classroom realities, but which was implemented purely for politico-ideological reasons. The curriculum was found to be highly sophisticated for the South African scenario. It was rich in ideology, new terminology and far different from that of the past. In 2000, Curriculum 2000 was reviewed and the Revised National Curriculum Statement (RNCS) was produced. The RNCS simplified and clarified the C2005, and this was completed in 2002 and implemented in 2004. Nonetheless, there were still some flaws in the curriculum.

In 2002, the National Curriculum Statement (NCS) for the FET Band was developed. The Curriculum was supported by policy documents and guidelines (i.e. Subject Frameworks and Assessment Guidelines). This curriculum was introduced to the FET Band in grade 10 in 2006, grade 11 in 2007 and Grade 12 in 2008. The Curriculum was regarded by the education authorities in South Africa to be internationally benchmarked and designed to provide learners with the knowledge and skills to participate actively in, and contribute to, a democratic South African society and economy (Reyneke, 2008:4).

The National Curriculum Statement consisted of twenty-nine subjects. Like the former OBE mandate, the curriculum aimed at redressing the imbalances of the past and establishing a society based on democratic values, social justice and fundamental human rights; at improving the quality of life of all citizens and free the potential of each person; laying the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected by law; and building a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations. It was based on the principles of social transformation, Outcomes-Based Education, high knowledge and high skills, integration and applied competence, progression, articulation and portability, human rights, inclusivity and environmental and social justice, valuing indigenous knowledge systems and credibility, quality and efficiency (DoE, 2003a:1)

The kind of learner that is envisaged by the curriculum was one who would be imbued with values and act in the interest of a society based on respect for democracy, equality, human dignity and social justice as promoted in the Constitution. The learner emerging from the FET Band should also demonstrate achievement of the Critical and Developmental Outcomes. Furthermore, they should have access to, and succeed in, lifelong education and training of good quality; demonstrate an ability to think logically, as well as holistically and laterally; and be able to transfer skills from familiar to unfamiliar situation (DoE, 2003a:5).

There is a specific relationship between the NCS principles and Physical Sciences because proficiency in the latter is seen as fundamental for accomplishing these principles in the country. Since Physical Sciences have an important role to play in society and education, the learning outcomes of Physical Sciences need to be practical and focussed. Its study must give learners the ability to work in scientific ways or to apply scientific principles that have proved effective in understanding and dealing with the natural and physical world in which they live; it should stimulate their curiosity, deepen their interest in the natural and physical world in which they live, and guide them to reflect on the universe; develop insights and respect for different scientific perspectives and a sensitivity to cultural beliefs, prejudices and practices in society, develop useful skills and attitudes that will prepare learners for various situations in life, such as self-employment and entrepreneurial ventures; and enhance understanding that the technological applications of the Physical Sciences should be used responsibly towards social, human, environmental and economic development both in South Africa and globally (DoE, 2003a:10). Thus, its learning outcomes must be practical and focused.

In reaching these outcomes new assessment standards had to be met and teachers were challenged to match assessment practice to educational goals. For the first time in the history of their employment they were confronted with various types, methods, tools and techniques of assessment that must be well understood and mastered in the teaching and learning of Physical Sciences. They were expected to find or develop their own teaching material to create the best possible context in which learning can take place, select the best teaching strategies, involve learners with purposeful learning activities aimed at attaining the learning outcomes, find the best ways of assessing learners' performance against certain criteria and use the assessment results to enhance both teaching and learning. Moreover, learners had to become partners in the whole process of teaching, learning and assessment and be guided into taking responsibility for their own learning (Reyneke, 2008:5).

The focus on learner involvement required schools and teachers to take major roles in curriculum design according to learners' experiences and needs. They were also expected to take major responsibility for the assessment of learners' achievements as both a guide to teaching and learning, as well as reporting and system accountability. Finally, systems of quality assurance and accountability had to be established for accountability to communities and the nation (Howie, 2002:44).

For these reasons, assessment posed one of the more complex problems that came along with changes in education. The Ministerial Task Team that reviewed OBE found that there was a lack of alignment between the curriculum and assessment policy (Chisholm, 2005:87). "Continuous assessment" (CASS) was Curriculum 2005's preferred mode of assessment, but this was interpreted by some as frequent testing, and resulted in the inevitable problem of accounting and recordkeeping in the classroom. This distracted teachers from teaching, and therefore less learning took place. Training programs and support were inadequate and often did not model the approaches they were promoting (Howie, 2002:44). Changing learning goals to become more process-oriented outcomes was one thing, but operationalising it in assessment was quite another task (Dekker & Feijs, 2003:1).

According to Dave Balt, the president of National Professional Teachers' Organisation of South Africa (NAPTOSA), the fact that every time someone raised the issue of assessment during the process of developing version one of C2005, he/she was told that it was either "a provincial competence" or "assessment is up to teachers in the classrooms" (NAPTOSA, 2001). These answers were not helpful, and as time went by no clear guidelines about how assessment should be implemented emerged. This reluctance to actually confront and deal with the issues around assessment was, according to Dave Balt, certainly one of the major factors that led to the ultimate rejection of the implementation of C2005 by teachers. This, along with poor training, undermined the self-confidence of teachers. Everything could have made sense in the end if teachers had been able to make sense of the assessment. Assessment is crucial for successfully getting OBE underway in all bands of education.

1.2 Problem statement

It is clear that from the onset of the implementation of OBE in South Africa teachers were confronted with unfamiliar didactical challenges with regard to teaching, learning and assessment of Physical Sciences in the FET Band. Most of these teachers experienced these challenges as very stressful, because they were inadequately prepared for the didactical paradigm shift. This resulted in a general degree of negativity and resistance towards OBE amongst teachers. In particular, there seemed to be much confusion and frustration about the workload and administrative burden that Outcomes-Based Assessment practise imposed on teachers.

Articles by Reddy (2004a), Le Grange (2004), and Maree and Frazer (2004:31) also indicated that many science teachers seemed to have an unclear understanding of what was required of them and were sceptical about a shift to continuous assessment (CASS) and whether the major increase in workload was justified in terms of potential gains.

Despite all these uncertainties, on 30 September 2004, it was all systems go for implementing the new curriculum for Grades 10 – 12. In her press release statement the then Minister of Education indicated that following the Cabinet's and the Council of Education Minister's approval of the National Curriculum Statement, Grades 10 – 12, it would be implemented in 2006. The final decision to implement NCS was based on the level of preparedness of provinces, which was based on the following four key indicators:

- The finalisation of the policy on the National Curriculum Statement (Grades 10- 12);
- The preparation of schools and teachers for the demands of the new curriculum;
- The development of relevant high quality Learning and Teaching Support Materials (LTSM); and
- The communication of the implementation plan to the education system and the public.

Provinces were then asked to prepare a three-year implementation plan, indicating the phasing in of a wider choice of elective subjects from 2007. According to the then Minister of Education, the Department of National Education and the Provincial Departments of Education were urged to have developed detailed plans to prepare teachers, school management teams and curriculum support personnel for the demands of implementing the new curriculum by the time of implementation. Teacher training, according to the plan, was to focus on strengthening subject content knowledge and teaching and assessment practices (DoE, 2004).

Since the issue of assessment is a wide concern that influences every level of the education system, it should be regarded as one of the most important catalysts for reform in the science curriculum. Teachers, subject advisors, curriculum designers usually face difficulties in judging whether assessment tasks are truly aligned with national or departmental standards and whether they are effective in revealing what learners actually know (Stern & Ahlgren, 2002:889).

Various sources indicate that assessment has a significant impact on teaching and learning and the development of the curriculum (Dochy & McDowell, 1997:285; Stern & Ahlgren, 2002:889; NAPTOSA: UPDATE, 2001; Pretorius, 1998:83; Reddy, 2004a: 33, 34 & 36; Brant et al., 2000:271; and Meyer, 2005:47-48). Pahad (1999:247) states that assessment practices are essential for the successful implication of OBE. If used properly, good assessment practices can be a powerful catalyst for improving the curriculum, teaching and learning. Poor assessment practices, on the other hand, can impoverish our expectations for learning science, focusing teachers' and learners' efforts on less important concepts and skills or on test taking as an end in itself (Stern & Ahlgren, 2002:889).

Since assessment is the driving force behind OBE, it is crucial that teachers master and implement the different types, methods, techniques and tools of assessment effectively.

Not all teachers are familiar with the concept of Outcomes-Based Assessment (OBA), and they consequently need to be properly trained how OBA should be implemented in classrooms and laboratories in order to achieve effective learning and teaching.

Group work and Continuous Assessment (CASS) are the only link that teachers seem to have with OBE and OBA. CASS is viewed by most teachers and learners as an unnecessary burden associated with many assignments for learners and much marking, paper work and administration for the teacher (Reyneke, 2008:8). Often CASS tasks do not flow logically from teaching and learning, so that the CASS mark is nothing more than a mark for a series of loose-standing summative assessment tasks instead of being a continuous formative process by which each learner is effectively developed to achieve the set Physical Sciences outcomes.

In the light of afore-mentioned, the following primary and secondary research questions emerge: [1]

Primary research question:

- What assessment model can be proposed to facilitate the effective assessment of Physical Sciences in the FET Band by considering both the literature and the practical experiences of teachers in the North-West Province?

Secondary research questions:

- What does the literature reveal about the elements of OBA of Physical Sciences in the FET Band?
- How do teachers in the North-West province experience OBA of Physical Sciences in FET Band
- What are the challenges or obstacles that these teachers experience with OBA of Physical Sciences in the FET Band?
- What sources/opportunities are there to support the OBA of Physical Sciences in the FET Band?
- Is there a relationship between teacher variables and the OBA of Physical Sciences in the FET Band?
- What assessment model can be proposed to facilitate the effective implementation of Physical Sciences in the FET Band?

1.3 Research aim and objectives

The overarching research aim is to develop an assessment model that can facilitate the effective implementation of OBA of Physical Sciences in the FET Band for secondary schools in the North-West Province of South Africa.

The research objectives are to:

- Explore the key concepts, fundamental principles and philosophy underpinning OBE and OBA of Physical Sciences in the FET Band;
- Determine how teachers in the North-West province experience OBA of Physical Sciences in FET Band;

[1] The researcher is aware that since this study started there has been a ministerial investigation into the implementation of the NCS in 2009, and that in general it covered aspects related to assessment as well. However, this study focused specifically on assessment of Physical Sciences in the FET Band in the North-West Province and research of this nature has not been done yet.

- Identify the challenges or obstacles that these teachers experience with the OBA of Physical Sciences in the FET Band;
- Determine what sources/opportunities are available to support the OBA of Physical Sciences in the FET Band;
- To determine whether a relationship exists between teacher variables and the OBA of Physical Sciences in the FET Band.

1.4 Research design and methodology

A literature survey as well as an empirical study was undertaken. In the following paragraphs only a brief discussion will be offered of the research design and methodology, because it will be dealt with in detail in Chapter 8.

1.4.1 Literature survey

A comprehensive literature study was conducted to acquire an understanding of the following: Outcomes-Based Education (OBE), Outcomes-Based Assessment (OBA), assessment and the National Curriculum Statement (NCS) and assessment of Physical Sciences. A DIALOG-search was conducted on the ERIC-database to explore relevant and recent sources on: Outcomes-Based Education, Outcomes-Based Assessment, Continuous Assessment (CASS), assessment of Physical Sciences, assessment of practical work in Physical Sciences. By using the NEXUS-database, relevant sources were traced and consulted. The Internet was also used to find further sources and information in this regard.

1.4.2 Empirical study

The empirical investigation was conducted by means of a survey. Qualitative and quantitative data were collected by means of a questionnaire.

1.4.3 Data collection instrument

A questionnaire consisting of 91 structured items and 10 unstructured (open-ended) items (see Appendix F) was developed and used to gather data from the participants. The instrument was divided into two sections. Section A collected demographic and biographical information from the participant, and Section B collected quantitative and qualitative data from participants about the OBA of Physical Sciences in the FET Band. The development, content and validation of the questionnaire will be discussed in detail in Chapter 8.

1.4.4 Sample

A representative sample of 111 schools was randomly drawn from 330 schools offering Physical Sciences in the FET Band in the North-West Province of South Africa. At each of these schools, any one teacher who taught Physical Sciences in the FET Band from 2007 to 2010 was invited to participate in the survey on a voluntary basis (see Appendix E).

1.4.5 Data analysis

The quantitative results emanating from the survey are presented in three sections. The first two sections deal with the participants' biographical details and their responses to the structured items of Section B of the questionnaire and are presented in the form of frequency tables. The Cronbach's Alpha coefficients were calculated to find the validity and reliability of Sub-Sections B4 and B5 of the questionnaire. This was followed by factor analyses. Lastly the relationship between certain biographical and location variables and factors related to OBA of Physical Sciences in the FET Band were investigated. For this purpose ANOVA's and t–tests were conducted.

Respondents' replies to the open-ended items of Section B of the questionnaire were written down (Appendix F) and analysed. Similar responses to the respective open-ended items were categorised and links between participants' responses to different open-ended items were investigated.

1.4.6 Ethical aspects

Permission to conduct the research was requested from the North-West Education Department (see Appendices A and B) and school principals (Appendix C). Participants participated voluntarily (see Appendix E) and the identities of schools and participants were not revealed.

1.5 Chapter division

The following chapters are included in the thesis:

Chapter 1 Orientation and problem statement
Chapter 2 An introduction to assessment and related concepts in sciences
Chapter 3 Learning theories and Outcomes-Based Education
Chapter 4 Outcomes-Based Education and the National Curriculum Statement
Chapter 5 Outcomes-Based Assessment and the standards of assessment

Chapter 6 The Outcomes-Based Assessment of Physical Sciences
Chapter 7 Outcomes and taxonomies of educational objectives
Chapter 8 Research design and methodology
Chapter 9 Results and conclusions
Chapter 10 A Model for the Assessment of Physical Sciences in the FET Band
Chapter 11 Summary and Recommendations

1.6 Summary

This chapter (Chapter 1) serves to orient the reader with regard to the study. A literature study related to the introduction of OBE and OBA in South Africa was offered to lay the foundation for the study. The challenges that the North-West Province teachers' experience with the implementation of OBA of Physical Sciences in the FET Band, the lack of resources, the research problem, the aim and objectives were stated. The research design and methodology that was implemented to address the research problem and to achieve the aims and objectives of the research were briefly discussed and information was given about the ethical considerations that guided the research. A brief exposition of the different chapters in the thesis was provided.

In the following chapters (Chapter 2 – 7), the key concepts, fundamental principles and the philosophy underpinning OBE and OBA of Physical Sciences in the FET Band are explored.

CHAPTER 2

AN INTRODUCTION TO ASSESSMENT AND RELATED CONCEPTS

2.1 Introduction

It is natural to want to know how well you did or how you are doing at a task or in a lesson, whether you are generally doing well in school, or whether you are productive in your job, or whether you are participating in family life at home. However, any person needs relevant information in order to make judgements about performance or progress. This information can be gathered using formal or informal assessment. Formal assessment, such as in a science experiment, usually involves a structural task that has to be completed or questions that have to be answered (Payne, 2003:4). Despite its importance, most science teachers look at assessment as an unpleasant task, one that unfortunately has to be done, and the quicker the better! This attitude, results in teachers frequently leaving assessment until the end of a unit or lesson. Some kind of test is then hastily developed and given to the learners. Sometimes the test fits what was taught, sometimes it is far removed. However absurd, this happens frequently (Trowbridge, Bybee & Powell, 2004:248).

What does it mean to assess in an educational setting (Payne, 2003:4)? Teachers sometimes misunderstand the broader aspects of assessment, including self-assessment by learners, assessment of laboratory work, diagnostic, formative, and summative assessment, and other aspects of the total assessment process. Most teachers received little formal training in assessment, and so their assessment methods traditionally tended to be formal, concentrating on quizzes and end-of-term tests. As a result, instruction and assessment are thought of as separate entities (Trowbridge et al., 2004:248).

It is difficult to find writers who address the purpose of assessment, or who asks what qualities assessment does or should have, or who examines its effects on the relationship between teachers and learners, or attempts to relate it to such concepts as truth, fairness, trust, humanity and social justice. They rarely give any indication of having considered questions of the latter kind. They appear to regard assessment as non-problematic. In addition, an adversarial relationship seems to exist between the assessor and those being assessed, thus minimizing the assessment's effectiveness and destroying one of the very reasons for doing it, namely the valid assessment of achievement, attitudes, skills development, and progress (Trowbridge et al., 2004:248).

The term assessment can have a variety of meanings for different people. Some of the confusion and false distinctions will become apparent as we begin exploring a working definition of assessment.

Specifically, this inquiry addresses educational assessment in science education. This chapter begins with a brief description of the term assessment, the relationship of assessment to other concepts, the purpose of assessment and definitions of the concepts comprehension and perception.

2.2 What is assessment?

The term assessment has been cast about so routinely in recent educational discussions, debates, and deliberations one would think that everyone knows what assessment is. Such an assumption is probably incorrect. There is certainly no standard usage of the term. It is used in so many different ways, in so many different contexts, and for so many different purposes, that it can mean almost anything (Cizek, 1997:8). This study will look at different definitions, and indicate those that suit the current educational scenario best.

Assessment can be defined as “any method used to better understand the current knowledge that a learner possesses.” This implies that assessment can be as simple as a teacher’s subjective judgement based on a single observation of learner performance, or as complex as a five-hour standardised test. The idea of current knowledge implies that what a learner knows is always changing, and that we can only make judgements about learner achievement through comparisons over a period of time. Assessment may affect decisions about grades, advancement, placement, instructional needs, and curriculum (Dietel, Herman & Knuth, 1991:1).

Dictionary definitions tend to agree that to assess is to put value on something, usually in financial terms. Such definitions clearly are not centred on educational assessment, although it is true that certain outcomes of educational assessment, e.g. a learner’s degree class, may well determine the salary he can expect. Again, such evaluation definitions do chime in with what many teachers think of (erroneously, I would say) as essential components of assessment, viz the assigning of numerical marks or letter grades, and the ranking of learners in order of preference or relative achievement (Rowntree, 1987:4).

The National Qualifications Framework (NQF) provides opportunity for people to learn, whatever their age or their previous level of education and training. It allows people to learn and gain education throughout their lives. This framework is not a formal one. Learners can gain their skills in many ways. They might learn on the job, they might go to a training college; they might do a short course. This means that the framework must provide ways to find out if a learner is competent. Competence means to have the knowledge, skill and ability to do something and to understand the context in which this activity takes place (Pahad, 1997:5).

The root of the word “assessment” is derived from the Latin verb *assidere,* which means “to sit beside,” Brainard, 1997:164 (as in Reddy, 2004a:32) and Dreyer, 2000:268. In mentioning this term it is likely that Brainard wishes to point out that in order to reveal what learners know, it is necessary to be close to them, perhaps even move alongside them as they pursue challenges of learning (Reddy, 2004a:32). In an educational context assessment refers to the process of observing learning, describing, collecting, recording, scoring, and interpreting information about a learner’s learning (Dreyer, 2000:268). At its most useful, assessment is an episode in the learning process; part of reflection and an autobiographical understanding of progress (Pahad, 1997:5; Pretorius, 1998:83 & Dreyer, 2000:268).

More basically, assessment in education can be thought of as occurring whenever one person is in some kind of interaction with another, whether directly or indirectly, and is consciously obtaining and interpreting information about the knowledge, understanding, abilities or attitudes of the person. It is to some extent an attempt to know a person. In this light, assessment is a human encounter. In education we are mainly conscious of this “encounter” in the shape of teachers finding out about their learners. However, one must not forget that learners also assess one another, especially when working together as cooperative teams. They also assess their teachers. Nor should we hesitate to turn the definition in upon itself and think of the person finding out about himself – self-assessment (Rowntree, 1987:4).

According to Freiberg and Driscoll (1996) as in Van der Horst and McDonald (1997:169), many of the terms in the language of assessment are interrelated. Doran, Lawrenz and Helgeson (1994: 388) believe that assessment can be defined as the collection of information, both quantitative and qualitative, obtained through various tests, observations, and many other techniques (e.g. checklists, inventories, survey, etc), that is used to determine individual, group, or program performance. Usually this type of assessment is employed in research surveys.

Learner assessment (Tamir, 1998:765) can be defined as the systematic collection of information about learner learning and other variables associated with particular learning experiences. It involves description of knowledge in at least two points of time, namely prior to the learning experience and upon completion of the learning task. Additional assessment might be considered while learning is taking place, or at various periods after the completion of the task (to measure retention).
At the very simplest level, assessment can be seen as the ability to see learners, to perceive what they can do in the hope of understanding how they learn and in order to assist their learning. It is an ever-present reality in the lives of teachers. Many view it as basically referring to the process of determining learner achievement (Reddy, 2004a:32-33). It is indeed an all-embracing term that covers any of the situations in which aspects of a learner’s education is in some sense measured,

whether this measurement is by a teacher, an examiner or indeed the learner him/herself (Jones & Bray, 1986:1, as quoted by Reddy, 2004a:33).

Pahad (1997:5) views assessment as the process used to decide if a learner is competent or not. A learner must show that he or she knows, understands and can do whatever is required to demonstrate competence. Van der Horst and McDonald (1997:169) define assessment as a strategy for measuring knowledge, behaviour or performance, values or attitudes. The measurement or data you gain from assessment helps you to evaluate.

Educational assessment is difficult to define. English and English (1958, as quoted by Payne 2003:5-6), define assessment as "a method of evaluating personality in which an individual, living in a group under partly controlled physical and social conditions, meets and solves a variety of lifelike problems, including stress problems, and is observed and rated." This intense process (Payne, 2003:6) involves a variety of data-gathering techniques (Van der Horst & McDonald, 1997:170) such as observations, stress interviews, performance measures, group discussions, individual and group tasks, peer ratings, projective techniques, and various kinds of structured tests. This kind of assessment is more of a psycho-analysis.

At least four definitions of assessment appear in current literature. To some teachers, assessment refers to new formats for gathering information about learners' achievement: for example, "portfolio assessment." To others assessment refers to a new attitude towards gathering information, an attitude that is perhaps kinder and gentler than that represented by standardised testing. The term assessment has also come to represent a new ethos, one of empowerment, in which assessments are designed and implemented primarily to serve the information needs of learners and teachers.

Each of these usages contributes to a definition of assessment. Firstly, any definition of assessment must be applicable to existing, emerging, and future conditions, formats, and contexts. All things being equal, a more general definition would be preferred over a narrow one (Cizek, 1997:9). Airasian (1994, as quoted be Cizek, 1997:9), suggests that assessment should include "the full range of information teachers gather in their classrooms: information that helps them understand their pupils, monitor their instruction, and establish a viable classroom culture." Even Baker and Stites (1991), as quoted by Cizek (1997:9), envision formal learner assessments of cognitive and non-cognitive characteristics in which "learners will need to demonstrate their commitment to tasks over time, their workforce readiness, (and) their competence in team or group performance contexts."

Second, it would be desirable for a definition of assessment to convey an attitude that enhances the position of assessment in instruction, so that teachers will readily embrace such a definition (Cizek, 1997:9). Cizek (1997:9) gives the example of his colleague who said that the portfolio assessment would never have achieved its current level of acceptance had it been called individual folder-based measurement. Third, a definition that recognises that assessments should serve as opposed to drive instruction would be preferable. Although there are still some proponents of what is called measurement-driven instruction, such a view was probably never in the mainstream of psychometric thought, even though this strategy has been used repeatedly, and successfully, to accomplish curricular aims (Cizek, 1997:9).

Finally, a definition of assessment should provide a link to educational processes that seek the welfare of each learner. It is possible to recognise that assessment has administrative use as well as instructional value. Nonetheless, it seems proper to weigh a definition of assessment more heavily as gathering accurate information that is relevant to learners' needs. Placing ancillary concerns above learners' needs has long been an enduring temptation. Lindquist (as quoted by Cizek, 1997:9), was quoted by Kohn (1975:20) as saying:

> "I have been rather disappointed in developments within the educational testing field. Tests seem to me to have gone farther away from higher and higher precision and more accuracy in measurement. There seem to be less of an effort to provide a really faithful, dependable picture of the abilities and aptitude of the individual child, and administrators, who are out to make a record, are more interested in average scores and how they may be used politically, and more interested, perhaps, getting the information needed for those purpose at a lower price in terms of both time and money".

Incorporating the preceding facets into a single definition of educational assessment yields the following proposed definitions:

Assessment \uh ses' ment\ (1) v.t.: the planned process of gathering and synthesizing information relevant to the purpose of (a) discovering and documenting learners' strengths and weaknesses, (b) planning and enhancing instruction, or (c) evaluating progress and making decisions about learners. (2) n.: the process, instrument, or method used to gather the information.

Learner assessment traditionally relied on measures, instruments and methodologies developed by measurement experts and based on measurement theories yielding quantitative data that served to rank individuals within a classroom, a school or a particular age cohort (Tamir, 1998:765).

Therefore, assessment is a planned process designed to accomplish a specific educational purpose with the primary beneficiary of the process being the learner (Cizek, 1997:10).

In Outcomes-Based Education the learning outcomes that the learner should attain are clearly defined. Through assessment, both teachers and learners are able to determine whether these outcomes have been achieved. Curriculum 2005 indicates that the learners' progress is measured against these outcomes rather than against his/her performance compared to other learners, and for this reason there will be no passing or failing. OBE means the attainment or achievement of learning outcomes. Although the words "passing" or "failing" are not used in the same way as in the past, it does not mean that learners will be able to advance without having achieved the required learning outcomes. Should learners advance automatically, it would make a mockery of all instructional endeavours (Van der Horst & McDonald, 1997:170)!

2.3 Assessment and other concepts

Many of the terms in the language of assessment are interrelated and sometimes used interchangeably or are confused with each other. The most used concepts are: measurement, testing, examination, evaluation, experimentation and practical work and assess, some of which will be discussed in the following paragraphs.

2.3.1 Measurement

Measurement is concerned with the systematic collection of data, its quantification and the result. It can take many forms, ranging from the application of very elaborate and complex electronic devices, to paper-and-pencil exams, to rating scales or checklists. The primary component of educational assessment is data collection. When measuring something, standard instruments such as rulers, scales of thermometers are usually used in order to determine length, weight and temperature. A numerical or quantifiable value is thus attached to measurement. This implies that the outcome of a measurement will depend largely on two things: the accuracy of the instrument, and the knowledge and skill of the individual using it (Lombard, 2010:33).

When collecting information about the learners' learning, the teacher collects information relative to a predetermined standard, such as scoring scale or rating sale, or a checklist. By applying a predetermined standard, a quantitative value is attached to a learner's response. In this sense, measurement forms part of assessment.

Thus, educational measurement is a process of gathering data that provides a more precise and objective appraisal of learning outcomes than could be accomplished by less formal and systematic procedures. Measurement is more than counting or sorting. It compares something with a unit or standard amount or quantity to represent the magnitude of the variable being measured. However, data can be gathered by either qualitative or quantitative means (Payne, 2003:7 & 8-9).

2.3.2 Tests and examinations

There is an on-going educational debate concerning the place of tests and examinations in assessment and the influence they have on the curriculum. There are educationalists like Madaus (1988, as quoted by Jacobs et al., 2002:291) who argue that tests and examinations distort the curriculum and teaching in several ways. On the other hand, Ebel (1979, as quoted by Jacobs et al., 2002:291) is one of the theorists who believe that tests and examinations have a positive influence on education. He (Ebel) argues that tests and examinations are essential for good education. A test is only one way to assess learners' performance (Marneweck & Rouhani., 2002:291).

A test is a particular form of measurement. Implicit in the term's current usage is the notion of a formal, standardized procedure in which the examinee is aware that she or he is being tested for a particular purpose at a specific time. Normative data also tend to be presented along with raw scores. A test might be defined as a systematic method of gathering data for the purpose of making intra- or inter-individual comparisons. In psychology, a test is regarded as a sample of an individual behaviour (Payne, 2003:7).

2.3.3 Evaluation

The starting point of assessment is evaluation – that is, the process of making a decision about the learning of the learner using information gained from formal and informal assessment. Evaluation requires that you should make a judgement about learners' knowledge, behaviour or performance, and values or attitudes. This enables a teacher to answer the question: "How good?" or "How well (Van der Horst & McDonald, 1997:169)?" Payne (2003:7) describes evaluation as a general process for making judgements and decisions. The data used to make evaluations can be quantitative, qualitative, or both. A teacher can draw on classroom exams, anecdotal material, scores from standardized tests, and informal observations in evaluating a child.

When evaluating, one is literally engaged in the process of making judgements about or deciding on the worth of something. Evaluation is concerned with the quality of a quantified or measured result. The result is evaluated by interpreting the information gathered through measurement. With regard to teaching and learning, the teacher is mainly concerned with the learners' achievement of the specified outcomes. By using an intended outcome as a benchmark and by comparing learners' achievement to this outcome during the process of lesson presentation, the teacher makes judgements about the learners' attainment of the outcome (Lombard, 2010:34).

Considering our previous discussions of assessment, tests, measurements, and evaluation, the following working definition of assessment is proposed:

"The interpretive integration of application tasks (procedures) to collect objective-relevant information for educational decision-making and communication about the impact of the teaching-learning process".

2.4 The role of assessment

Critics of assessment claim that: "Pigs are not fattened by being weighed". They wonder why time, thought, and money are invested in assessing, when it would be better to concentrate on the business of teaching, or on research. They believe that pressure for assessment reform is just another example of researchers trying to hog-tie teachers, finding busy-work for them to do that will produce information which will probably not be used or, if it is used, will somehow be used against teachers, rather like the league tables have been used against schools (Brown & Knight, 1995:11).

Brown and Knight (1995: 31-32) came up with (to mention just a few points) the following disadvantages of assessment:

- Assessment frees learners from the treadmill of continuous subject work, allowing them to read around the subject.
- Consequently, it allows them to experiment and to play with ideas, to explore unpromising avenues and to follow intellectual curiosity.
- Continuous assessment leads to a regression to the mean – put another way, it is hard to sustain a first-class standard over many pieces of assessed work, easier to do so over fewer pieces.
- It encourages "surface" approaches to learning. Essentially, "surface" approaches involve memorization and reproduction above all. "Deep" learning, on the other hand, involves a quest for understanding and involves an interaction with the new information, which is substantially worked in the learning process.
- Excessive assessment, especially where the assessments are clichéd, leads learners to adopt surface learning as a coping strategy.
- It puts a premium on coverage of content at the expense of depth of understanding – superficial acquaintance is encouraged.

- Assessments are often unreliable, hence arbitrary, and the range of assessment techniques that the learner encounters, is likely to be equally arbitrary.
- It wastes an enormous amount of staff time.
- It produces seemingly ‘hard’ data about learner performance, which are used as performance indicators, when in fact the data, coming from frequently invalid measures, and being an excessively simplified description of the results, are of very little value.
- It conceals the importance of thinking intelligently about the whole business of learning and teaching, perpetuating nineteenth-century practices while we are in the twenty-first century, because the system is ‘comfy’ and appears to work.

Brady (1996) has already noted the considerable sums of money spent on assessment and that recent curriculum developments require classroom teachers to spent much time and effort on the formal assessment of their pupils and learners. It is therefore important that the education department clarifies the uses to which assessment can be put. Recognising that there is a plurality of purposes reminds us that this is a complex and sensitive assessment procedure that needs to achieve maximum validity and reliability, but they will be of no value if they are misused (Brady, 1996:10-11).

Two reasons for “doing” assessment come to mind rather quickly. First, assessment is what teachers can do in order to demonstrate that they actually do what they say they do. It is our source of in-process feedback. As opposed to grades, assessment decomposes the curriculum (or an assignment, class, or course) into component parts and makes those parts visible. Second, assessment satisfies the demands for accountability by external agencies. Physicians, surgeons, lawyers, and nurses all practice their professions daily in front of their peers. They are constantly subject to peer review and feedback. Professors are perhaps the only professionals who habitually isolate themselves from peers behind closed (classroom) doors, there to practice the major activity for which they receive payment. Given the immense costs of higher education, if the faculty don’t use assessment to provide accountability, surely someone else will do so (Eder, 2005:1).

Assessment includes several purposes, such as diagnosis, evaluation, grading. However, these are not ends in themselves, of course. They are means towards further ends. In general the beneficiaries can be seen to be the learner, his teacher and “other people” (often referred to as “society” – chiefly comprising parents, teachers and administrators in other educational institutions, and employers). Who benefits in particular instances depends on the nature and purpose of the assessment (Rowntree, 1991:15), e.g. formal or informal, formative or summative, pedagogic or classificatory, process or product, criterion referenced or norm referenced, individual focused or group focused, continuous or end point, learner judged or teacher judged, and internal or external (Harris & Bell, 1996:98 and Rowntree, 1991:15).

A recurring message is that assessment may be many things for many people, for example: the learner/learner; other learners/learners; tutor; mentors; employers; university management; financing and other government bodies; and funding councils. Depending on those people's interests, assessment needs to take different forms; have different levels of reliability and validity; be done at different points in learners' schooling careers; and have its findings communicated in different ways (Brown & Knight, 1994: 13).

It is very important to examine more closely why we assess, so that the assessment we choose to undertake can be conducted for sound and expedient reasons.

2.4.1. Learners expect it

Most learners in FET schools have at least nine years of formal education behind them, and assessment has usually formed a considerable part of this process. Throughout this time, they had their energies regulated and learning activities punctuated by assessment, and they expect the FET-band to be the same (Brown & Knight, 1995:33). Assessing learners can be a very meaningful activity for them. They learn how well they have done. Moreover, although additional potential functions of assessment, such as providing feedback to the learners and the teachers, are cited in books, these functions are often played down in practice (Tamir, 1998:765).

Assessment empowers learners to evaluate their own and others' work and encourages learners to take responsibilities for their learning. Group assessment encourages co-operation amongst learners, social skills, time management and group dynamics (DoE, 2003a:58).

2.4.2 Multi-purpose for learners

Assessment can provide feedback. One of the most common complaints learners have is about unmarked assignments. They can become very dissatisfied when they put much energy into completing an assessment task, which then seems to be ignored by the tutor. They tend to express views such as that there is no point in doing further assignments because they never get their work back. Receiving feedback can be an excellent motivator, especially when valid criticism is supported by appropriate praise and commentary (Brown & Knight, 1995:33).

Assessment can help learners remedy mistakes. If learners do not get feedback, they may continue to make the same mistakes repeatedly and fail to improve performance. Learning should not be a guessing game in which learners have to estimate what might be in a tutor's mind and then perform accordingly. They should be clear about the demands of assignments so that they have every chance to achieve well. They also need clear guidance as to what they might have done better in assignment tasks, so that they can improve the next time, and so that they learn appropriate material for examinations and for application beyond the learning environment. In short, assessment indicates readiness for progression; helps diagnose faults; and provides a performance indicator for learners (Brown & Knight, 1995:34-35).

Assessment helps learners to judge their own performance, set goals for progress and provoke further learning (DoE, 1999:18).

2.4.3 Selection and placement

Creating an effective assessment task takes considerable effort. It can and should be a meaningful activity. The role of assessment and evaluation in education has been crucial, probably since the earliest approaches to formal education (Dochy & McDowell, 1997:279). Assessment results have typically been used for selection and classification (Redy, 2004:33), for example, by serving as criteria for admitting candidates to prestigious schools for medicine, law or business (Tamir, 1998:765).

Whether for academic or vocational purposes, assessment can provide information that will aid individual and institutional decision making. Schools, colleges, and universities must select those learners most likely to benefit and succeed in their programs (Payne, 2003:17-18). Though the examination results are used to select those learners considered “suitable” for entry to further education, it often forms hurdles over which learners have to jump in order to continue with their chosen course of study or to obtain specific qualifications or credits for employment (Rowntree, 1991:17).

One of the assumptions implicit in selection tests for advanced education is that only the brightest, most promising, and patently talented should be funded to continue (Rowntree, 1991:17). Vocational training institutions are forced to make similar decisions (Payne, 2003:18). Another obvious goal, which applies to any form of vocational education whatever the level, is to ensure that the minimum standards required for occupational practice have been achieved. However, restriction of entry into an occupation through the use of assessment can be seen not so much as protecting the interests of the public at large, but as protecting the interests of the profession (Brady, 1996:11).

As both jobs and places in further and higher education are limited, such selection again brings in the idea of competition. The relationship between assessment procedures and further study or work opportunities is often tenuous. The advent of competence-based vocational education can be seen as an attempt to remedy this, although it certainly brings problems of its own. Basically the problem is that assessment that looks back in time to see what learning has been achieved is also used to predict suitability for a particular future programme of study or for a particular occupation (Brady, 1996:12-13).

Selection tests are probably what most people think of when they talk about assessment. Actually, it is often somewhat euphemistic to call them "selection" tests. For the majority of candidates many such tests rather function as rejection tests (Rowntree, 1991:16). The only quality of an institution they measure is how hard it is to get in, and how much it costs.

One place where assessment can be very useful is in cases where it provides learners with suitable information concerning their options where choices are offered. If, for example, learners must decide between Physical Science and Mathematics as their major subject, it is helpful for them to have some kind of external indicator of their own performance, rather than relying on personal preference or gut reaction. Indeed, if a learner goes on to choose the option that assessment suggests is his or her weaker subject at least this is an informed choice (Brown & Knight, 1995:34).

2.4.4 Predictive

In all of these cases, if it is assumed that "those who score well now will score well later", then assessment is used as a predictor of future potential. Although often used in this way, many studies have shown that commonly used assessments have little predictive value of an individual's future performance. Even the results of examinations used for selection into higher education in a similar subject area rarely indicate a high degree of correlation. A higher correlation with future performance may well be found between the learner's motivation, and/or style of learning, than between traditionally used predictors (Harris & Bell, 1996:90-91).

2.4.5 Multi-purpose for teaching

Assessment could serve to support teaching and learning, provide information about pupils, teachers and schools, act as an accountability procedure, and drive the curriculum (Redy, 2004:33). Not only does it serve to support teaching and learning, it is an integral part of teaching and learning, not just a means of monitoring or auditing learners' performance (although it does serve this purpose as well).

Before we consider the how of assessment, we have to decide why we want to assess our learners. The ultimate purpose of assessment is to measure learning outcomes. The additional purposes are improvement of teaching, the curriculum and conditions for learners' learning (Van der Horst & McDonald, 1997:173).

If one or two learners do badly in an assignment, we can usually assume that it is the learners who need attention, but where a whole cohort hands in inadequate or incorrect work, this indicates some kind of failure in the teaching or assignment briefing methodologies. We then have fairly firm indicators that something needs to be changed, and often some hints on how we should do so. Some teachers may choose to use learner results as an indicator of their own excellence as a teacher during their appraisal or in negotiations for promotions or additional performance-related pay (Brown & Knight, 1995:35-36).

We are normally expected to make qualitative decisions about the levels of achievement our learners attain, and assessment enables us to do this. No one would expect to decide a final-year learner's degree classification simply on a hunch or a subjective response, so assessment of some kind will be necessary. It is vital to avoid over-reliance on any one single method of assessment, an examination, for example, as the only form of assessment, because it disadvantages some learners. It is normally advisable, therefore, to use a varied repertoire of assessment methods that can give a more valid and reliable picture of a learner's ability than reliance on a single methodology can (Brown & Knight, 1995:35).

However, change in this topic/area has been dramatic in the last few decades, largely due to wider developments in society. The most dramatic change in our views of assessment is represented by the notion of assessment as a tool for learning. In the past, we saw assessment only as a means to determine measures and thus certification, but there is now a realisation that the potential benefits of assessing are much wider and impinge on all stages of the learning process (Dochy & McDowell, 1997:279).

Teachers use assessment procedures for various purposes. Among the well-known and accepted ones are instructional purposes (to adjust instruction to learner level), evaluation purposes (to determine progress in learning), diagnostic purposes (to diagnose learning problems), make grouping decisions and placement purposes (to assign learners to different levels or courses), monitor learner progress and reporting purposes (to report to parents or to the learners themselves), and accountability purposes (to account for educational productivity to administrators) (Blok, Otter & Roeleveld, 2002:177). Teachers carry out curriculum evaluation and refinement. Assessment provides mastery and motivates learners (Dietel et al., 1991:1-2).

In public schools the demands for data is ever-increasing. Hundreds of decisions in and about school and schooling are made each day. We need the best information available, but technical adequacy must be balanced by practical considerations. If assessment, particularly state or federally mandated tests are abandoned as some critics would have it, negative consequences could result (for example, the distinction between competent and less competent individuals would be very difficult to make) (Payne, 2003:4).

Once a teacher has made a thorough assessment, he/she has an indication of how to improve his/her teaching. Evaluation acts as feedback in the experimental process of teaching. A teacher must experiment in order to progress and become more skilled. She must be willing to try new methods and new techniques, and, by so doing, evolve toward teaching mastery (Trowbridge et al, 2004:249). One of the reasons for the popularity of classroom assessment with teachers is that it is a creative activity, directed and applied by teachers to satisfy their own intellectual curiosity about their work (Cross, 1998:41).

Teaching means interacting with learners to engage them in the intellectual work of learning. Most of our memorable learning experiences either came from someone who cared a lot and motivated us to do our best, or in the best of all possible worlds, from teachers who excelled in both intellectual excitement and interpersonal rapport (Messick, 1998:4). It is for this reason that one of the advantages of classroom assessment that is mentioned most frequently by teachers is the bonding that is formed between learners and teachers when teachers demonstrate their own interest in using assessment for self-improvement (Cross, 1998:43).

Moreover, advantages of classroom assessment lie in the shift of emphasis from studying the characteristics of teachers to looking at the process of teaching. This enables us to consider context. Teaching is highly context-specific. Thus, studying the dynamics process of teacher-learner interaction in a particular context will tell us more than studying the static, and sometimes unalterable, characteristics of teachers (Cross, 1998:38).

2.5 What assessment is not

It has long been recognized that what teachers teach and the ways in which they teach are heavily influenced by particular types of assessment, especially external tests and examinations, such as the National Senior Certificate Examinations. When learners are prepared for these tests, the principle that assessment should complement the curriculum tends to be reversed so that the curriculum becomes assessment driven. Whether this influence is a force for good or ill, examinations have adverse effects on curricula. Many abilities, especially practical work ones, are not amenable to assessment in this way (Brooks, 2002:16-17).

Climbing the mountain without knowing the terrain is foolish, albeit possible in favourable circumstances. Teaching mathematics without a grasp of the range of the classroom management techniques is also possible, but circumscribed and inefficient. The weakest claim is that much the same could be said of learners who have only a small assessment component. It is quite possible that learners would learn, but without information about what they know, understand and can do, intuition would guide the teachers' activities and we might expect inefficiencies to prevail. Moreover, if teachers had not thought about assessment, there is every chance of a narrow, rather well-worn range of assessment techniques being used to assess something, and probably no one is too sure of what was being assessed (Brown & Knight, 1994: 12).

Traditionally, examinations have also acted as a disincentive to change and experimentation by teachers, thereby preserving an externally imposed status quo. To sum up, the deleterious effects that assessment has on curriculum and pedagogy are usually associated with high stakes assessment, which invariably takes the form of external tests and examinations (Brooks, 2002:17).

Although classroom assessment is preferred over any other assessment, the focus of classroom assessment is on learner learning rather than on school performance. Rather than learners judging the performance of their teachers, which has a ring of audacity to it, teachers and learners together are assessing what learners are learning in the classroom (Cross, 1998:38).

It should be clear that assessment is a planned process designed to accomplish a specific educational purpose, with the primary beneficiary of the process being the learner. In developing and implementing a definition of assessment, it should be remembered that such purposes ought to be secondary uses of educational assessment information. At the same time, it is important to retain a useful distinction between assessment as an integrated aspect of instruction and assessment as dissociated from instruction for the purpose of evaluation. In the former case, the assessment is embedded in instruction events. Such embedding is increasingly common. Indeed, not only is it a truism that learners learn from exposure to assessment, but there are also situations in which a particular assessment constitutes the entirety of a desired instructional event (Cizek, 1997:10).

2.6 Conclusion

People are willing to invest in institutions if it can be shown that what they produce is superior to anything that can be conjured up by other means. Education providers know implicitly in their souls the value of what they do. The public does not, and it won't tolerate institutions that cannot demonstrate that they produce a quality product. What is the quality of our product? How do we measure it authentically? How do we communicate it effectively to those who are buying it or making policy decisions? That's why we "do" assessment (Eder, 2005:2).

It should be noted that assessment that is convincing and valuable, is assessment that is authentic and valid. It should provide indications of learner achievement in the most effective and efficient manner, and ensure that learners integrate and apply knowledge and skills.

Understanding the meaning of the concept assessment, will help us understand Outcomes-Based Assessment, to benchmark Outcome Based Assessment, and to judge which procedures are educationally sound in Outcomes-Based Assessment.

Against the background of the discussion on assessment and related concepts, its purpose and educational implications, chapters 5 and 6 discuss assessment as a tool for the teaching and learning of science.

CHAPTER 3

LEARNING THEORIES AND OUTCOMES-BASED EDUCATION

3.1 Introduction

In teaching science to learners, teachers necessarily act as both interpreters and translators of scientific ideas. They not only engage with the ideas and explanations of science in order to develop a personal understanding of the subject, but also translate appropriate knowledge into learning experiences for learners. This is designed to help learners build increasingly more complex and scientific explanations of the world around them (Heywood, 2005:447). According to Project 2061 (as quoted by Bigge & Shermis, 2004:13), cognitive research reveals that even with what is taken to be good instruction, many learners, including academically talented ones, understand less than we think they do. With determination, learners taking an examination are commonly able to identify what they have been told. Their understanding is limited or distorted, if not altogether wrong.

Learning is a process. A teacher's view of the nature and source of human motivation greatly influences his/her outlook with regard to the nature of the learning process (Bigge & Shermis, 2004:13). Thus, teachers' attachment to a theory influences his approach to teaching and teaching styles. This has to be linked with the learning processes of our learners. It is very important to look at the different learning theories and find the relationship between learning theories and Outcomes-Based Education. Understanding the relationship will enable teachers to effectively implement Outcomes-Based Assessment, as most teachers do not have formal training in OBA. Therefore, this chapter will be dedicated to learning theories, up to and including constructivism.

3.2 Learning

Learning is the means through which people acquire not only skills and knowledge, but also values, attitudes, and emotions (Ormrod, 1990:6). Just what do we mean by the term learning? Theorists disagree about how to define the term. Some theorists propose a definition such as one of the following:

Definition 1: Learning is a relatively permanent change in behaviour due to experience.
Definition 2: Learning is a relatively permanent change in mental associations due to experience (Ormrod, 1990:6 and 1995:231).

There are two ways in which the definitions are similar. First, both speak of learning as involving a "relatively permanent change". In other words, the change will last for some period of time, although not necessarily forever. Also, both definitions attribute that change to experience. In other words, learning takes place as a result of some event in the learner's life. Other changes, such as those due to maturational changes in the body, 'organic damage' and temporary body states, (e.g., fatigue, drugs), are not attributable to experience, and so do not reflect learning (Ormrod, 1990:6).

The differences between the two definitions are as follows: The first speaks of a change in behaviour, an external change that can be observed. The second focuses on a change in mental associations – an internal change that cannot be observed. Herein lays the most fundamental difference in perspective in the theories of learning. The first definition reflects the perspective of a group of theories collectively known as behaviourism. These theories focus on the learning of tangible, observable behaviours, or responses. The second definition reflects the perspective of a group of theories collectively known as cognitivism. These theories focus on the thought process (sometimes called mental events) involved in human learning rather than on behavioural outcomes (Ormrod, 1990:60).

The above two definitions of learning correspond with the Bigge and Shermis' (2004:1) definition that defines learning to be an enduring change in a living person that is not heralded by genetic inheritance. It may be considered a change in insights, behaviours, perceptions, motivation, or a combination of these. It always involves a systematic change in behaviour or behavioural disposition that occurs as a consequence of one's experience in some specified situation. Teachers can do little to influence the maturational patterns of learners, except perhaps to accelerate or retard them to some degree. Their most effectual area of endeavour always centres upon learning (Bigge & Shermis, 2004:1).

Most psychology textbooks, e.g. Ormrod, 1990, 1995; Hamilton and Ghatala, 1994; and Bigge and Shermis, 2004, define learning as a change in behaviour. In other words, learning is approached as an outcome – the end product of some process. It can be recognised or seen. This approach has the virtue of highlighting a crucial aspect of learning, namely change. Its apparent clarity may also make some sense when conducting experiments (Smith, 1999:1).

Learning is not the lifeless, sterile, futile, quickly forgotten stuff that is crammed in the mind of the poor helpless individual tied into his seat by ironclad bonds of conformity! It should be insatiable curiosity that drives the adolescent boy or girl to absorb everything he/she can see or hear or read about for instance gasoline engines in order to improve the efficiency and speed of his "cruiser". I am talking about the learner who says, "I am discovering, drawing in from outside, and making that which is drawn in a real part of me." I am talking about any learning in which the experience of the learner progresses along this line: "No, no, that's not what I want"; "Wait! This is closer to what I am interested in, what I need"; "Ah, here it is! Now I'm grasping and comprehending what I need and what I want to know!" Carl Roger (1983:18-19; as quoted by Smith, 1999:1).

For all the talk of learning amongst educational policymakers and practitioners, there should be a full understanding of what learning entails. Theories of learning do not figure strongly in professional educational programmes for teachers and those within different arenas of informal education. It is almost as if it is something unproblematic that can be taken for granted. This lack of attention to the nature of learning inevitably leads to an impoverishment of education. It isn't simply that the process is less effective as a result, but what passes for education can actually diminish well-being (Smith, 1999:1-2).

The focus on the process of learning obviously takes us into the realm of learning theories – ideas about how or why change occurs.

3.3 The concept theory

The term theory is defined by Hamilton and Ghatala (1994:3-4) as a set of related general statements used to explain particular facts. The related general statements have been called axioms, theorems, assumptions, principles, or laws. Unlike Hamilton and Ghatala, (1994), Bigge and Shermis (2004:2-3) use the term theory as a designed plan for the development of a pattern of ideas accompanied by a planned procedure for carrying it out. Hence, it is a policy proposed and followed as a basis for action.

Scientific theories guide research scientists and help them develop new insights into the intricacies of nature. For that reason, a theory is an effective intellectual tool that integrates many observations and helps scientists make predictions. Well elaborated, it is an empirically substantiated explanation of some aspect of the natural world based on evidence. By nature, a theory incorporates facts, inferences, tested knowledge, and laws (Trowbridge et al., 2008:20). The function of the theory may be to lead to the discovery of new facts. Each time a new fact is correctly predicted by the theory, we not only gain a bit of information about the world, but, in addition, the theory gains validity or credibility. Another function can be to summarize and inter-relate a set of separate facts. It is much easier to remember a few general principles than a whole list of facts. It can also explain facts or observations (Hamilton & Ghatala, 1994:4-5).

Not only have people wanted to learn, but often their curiosity has impelled them to try to learn how they learn. Since ancient times, at least some members of every civilized society have developed, and to some degree tested, ideas about the nature of the learning process. In this manner they developed their respective learning theories (Bigge & Shermis, 2004:2).

A learning theory therefore is a set of general statements that explain particular facts about learning (Hamilton & Ghatala, 1994:224). It is a systematic integrated outlook with regard to the nature of the process through which people relate to their environments in such a way as to enhance their ability to use both themselves and their environments in a most effective way. According to Trowbridge et al. (2008), a learning theory should provide well substantiated explanations for aspects of teaching and learning in science classroom. It should help a teacher to specify the most:

- acceptable evidence that learners have learned,
- effective experiences to enhance learning,
- effective way in which knowledge can be structured to enhance learning,
- effective sequence in which to present material,
- effective processes for feedback and evaluation.

Everything teachers do is coloured by the psychological theory they hold. Even though they may not be able to describe their theories in explicit terms, we can usually deduce that which they cannot verbalise from their actions. Consequently, teachers who do not make use of a systematic body of theory in their day-by-day decisions behave blindly; little evidence of a long-range rationale, purpose, or plan is observable in their teaching. Thus, teachers without a strong theoretical orientation inescapably make little more than busy-work assignments. True, some teachers operate in this way and use only a hodgepodge of methods without theoretical orientation. However, this muddled kind of teaching is undoubtedly responsible for many of the current adverse criticisms of public education. Teachers need not base their thinking on traditional and folklore. They may be quite aware of the more important theories developed by educational psychologists, in which case their own psychological theories are likely to be quite sophisticated. Teachers who are well grounded in scientific psychology, in contrast with "folklore psychology", have a basis for making decisions that are much more likely to lead to effectual results in the classroom (Bigge & Shermis, 2004:5).

At least eleven different theories with regard to the basic nature of the learning process are either prevalent in today's schools or advocated by the contemporary psychologist. They are: Theistic mental discipline; humanistic mental discipline; natural enfoldment; apperception or Herbartianism; S-R bond; conditioning with no reinforcement; conditioning through reinforcement; gaol insight; narrative-centred cultural interaction; sequential-linear cognitive interaction and cognitive-field situational interaction (Bigge & Shermis, 2004:8). None of these theories will be dealt with in depth, but only selected science learning theories will be discussed. Just to shed some light on what these theories are all about:

The first four, namely the two mental discipline theories of the mind substance family, natural unfolding or self-actualization, and a-perception were developed prior to the twentieth century, but continue to be highly influential in today's schools. Mental discipline, of both kinds, means that learning consists of learners' minds being disciplined or trained. In teaching non-readers to read, teachers who are committed to mental discipline teach in such a way as to exercise the "muscles" of learners' minds. These teachers would list words that they wanted learners to be able to recognise, read, and spell, using flash cards in teaching them. They would drill their learners extensively, test them daily, and have the low achievers return after school for further drilling. There would be "recitations," within which learners would be drilled orally and take turns reading passages of their daily lessons. Learners would be driven to stay with their lessons, thereby strengthening their perseverance and willpower. Strict discipline would be maintained in order to strengthen the faculty of attention as well as those of memory, will, and perseverance ((Bigge & Shermis, 2004:9-10).

Natural unfolding or self-actualization, the extreme opposite of mental discipline, is a process along which a child unfolds what Nature or a Creator has infolded within that child. Teachers who adhere to this position would first wait for learners to express a desire to learn to read before they would make any attempt to teach them. Then, the teachers would be much more concerned with the children's maturational development than with inculcation of any specific skills. Furthermore, they would make sure that each child's learning is a joyous experience (Bigge & Shermis, 2004:10).

A-perception is a process of new ideas associating themselves with old ones that already constitute a mind. A-perceptions would teach learners to read by starting with the alphabet and making sure that the learners could recognise and say each letter. They then would tell the learners how letters are put together to make words, how letters make sounds, how sounds are telescoped together, and how vowels and consonants work. In other words, teachers would give them rules. They would be concerned primarily with making reading interesting and being sure that their learners got the right ideas from their reading (Bigge & Shermis, 2004:10).

Stimulus-response (S-R) bond, conditioning with no reinforcement, and conditioning through reinforcement are encompassed by the generalized concepts of S-R conditioning theory and behaviourism, which may be used interchangeably. Likewise, goal insight, narrative-centred culture interaction, linear cognitive interaction, and cognitive-field interaction are representatives of the cognitive-interactionist family. For behaviourists, learning is a change in observable behaviour, which occurs through stimuli and responses becoming related according to mechanistic principles. Stimuli, the causes of learning, are environmental agents that act in on an organism so as to either cause it to respond or to increase the probability of a response of a certain kind. Responses, effects, are physical reactions of an organism to either external or internal stimulation (Bigge & Shermis, 2004:11).

Cognitive interactionists regard learning as a process of gaining or changing insight, outlooks, expectations, or thought patterns. In thinking about the learning processes of learners, these theorists prefer the term person to organism, psychological environment to physical or biological environment, and interaction to either action or reaction. Such a preference is not merely a whim; there is conviction that the concepts person, psychological environment, and interaction are highly advantageous for teachers in describing learning processes. They enable a teacher to see a person, the person's environment, and the interaction between the two occurring all at once; this is the meaning of field (Bigge & Shermis, 2004:10-11).

3.4 Learning theories

Research on learner learning has long been an important factor in any teacher's instructional theory (Trowbridge et al., 2004:22). It is like the old story of the blind men and the elephant. Each feels one part of the animal and thinks it is the whole animal (Fisher, 1995:11). Conceptions of learning are an important element of a learner's (or learners') make-up. Vermunt (1998, as quoted by Newton, 2000:137) demonstrates that conceptions are one of the learner's attributes that are associated with his or her learning approach. The following represents some of the main research findings on learning theories from the 1960s.

3.4.1. Piaget J (1896 – 1980)

In the 1960s and 1970s, science teachers looked to Jean Piaget's theory of cognitive development. The research focused on two major features of Piagetian theory. Firstly, Piaget proposed that learning occurs through an individual's interaction with the environment. This interaction is described as assimilation of new information and ideas from various educational experiences and the accommodation/integration of new information with previously held information, thus establishing a consistency between the individual's cognitive structure and everyday experience (Trowbridge et al., 2008:22-23). Ormrod (1995:36) reiterates this when he says that assimilation and accommodation typically work hand in hand as children develop their knowledge and understanding of the world. Children interpret each new event within the context of their existing knowledge (assimilation), but at the same time may also modify their knowledge as a result of a new event (accommodation). Thus our learners can only benefit from new experiences when they can relate those experiences to their current understanding of the world. When we present new material to learners who don't have the relevant background knowledge about a particular topic, they will have difficulty assimilating or accommodating the new material (Ormrod, 1995:36).

Secondly, each individual passes through different stages of development, each characterised by the ability to perform various cognitive tasks (Trowbridge et al., 2008:23). For example, the ability to reason about abstract ideas emerges only after children are already capable of reasoning about concrete objects and events. The order in which various conservation task are mastered is much as Piaget proposed. Researchers are beginning to question the ages at which various abilities actually appear. They also found that the development of stage-related characteristics can sometimes be accelerated with training, and learners' logical reasoning capabilities are to some extent a function of their previous knowledge and experiences. Many researchers doubt that the development of logical reasoning is stage-like as Piaget proposed, because they believe that children are not always equally logical or illogical on tasks in different content areas (Carey, 1985; Donaldson, 1978; Field, 1987; Gelman & Baillargeon, 1983; Siegael & Hodkin, 1982; Siegler & Richards, 1982) as in Ormrod, 1995:50. As a result, the concept of stages of concrete and formal reasoning has been criticised and revised. Several studies (as quoted by Trowbridge et al., 2008:23) have demonstrated that as measured by performance on cognitive tasks, the majority of secondary school learners (FET) are at the concrete stage of reasoning. Thus performance on such tasks is strongly influenced by context, mode, language of task presentation, and subject matter (Trowbridge et al., 2008:23).

Nevertheless, with a few exceptions, Piaget's description of the four stages gives us a rough idea of when we can expect to see various capabilities emerge. At the same time we must remember that age alone is not the sole determinant of logical reasoning capabilities. Learners' previous experience with the topic under consideration also plays a significant role. Regardless of the possible weaknesses of Piaget's theory, Piagetian tasks can provide insight as to how our learners think and reason. We must remember that different children develop at different rates, so not all of our learners will reach cognitive milestones at the same time. We can determine the reasoning capabilities of our learners by presenting tasks involving either concrete or formal operational thinking skills and observing learners' responses to such tasks. We can then tailor our classroom curriculum and instructional materials accordingly.

The most relevant stages for science education are concrete reasoning and formal reasoning. Simply put, a concrete reasoner requires tangible objects and experiences and their observable relations in order to reason logically, and formal reasoner can manipulate abstract ideas. Piaget's notion of learning as an interaction with the environment has been generally supported and, in fact, was the foundation for contemporary constructivist explanations of learners' conceptual understanding and exchange (Trowbridge et al., 2008:23).

Most learners in secondary (FET) schools engage primarily in concrete reasoning, and therefore one should be careful when introducing tasks that primarily require formal, abstract thought. For example, most texts of secondary science implicitly assume that the reader can reason at the formal level. A statement about where learners are in their level of reasoning ability does not, however, mean they cannot learn and develop more sophisticated levels of reasoning. Learners much younger than secondary school learners are capable of logical reasoning and logical thought under certain conditions. Appropriate contexts and experiences that progress from concrete to abstract could foster the reasoning abilities necessary for understanding many science concepts (Trowbridge et al., 2008:23).

Applying Piaget's theory, Ormrod (1995:51) proposes that teachers should:

- Provide hands-on experiences with physical objects. Allow and encourage learners to explore and manipulate things.
- Ask learners to explain their reasoning, and challenge illogical explanations.
- When learners show signs of egocentric thought, express confusion, or explain that others think differently.
- Be sure learners have certain capabilities for mathematical and scientific reasoning (e.g., conservation, reversibility, proportional reasoning, and separations and control of variables) before requiring them to perform tasks that depend on these capabilities.
- Relate abstract and hypothetical ideas to concrete objects and observable events.

Quoting Osborne and Wittrock (1983) and Piaget (1978), Palmer (2005:1854) indicates that the "cognitive constructivist" viewpoint developed from the ideas of Jean Piaget, and he emphasises the importance of the cognitive process that occur within an individual. This type of learning can be triggered by experiences that can be physical, mental, or social: physical interaction with objects in the environment; mental experiences involve thinking about things they have observed; and social experiences include interactions with adults and peers (Palmer 2005:1854). This will be further dealt with in paragraph 3.4.3.

3.4.2. Information processing theory

A primary focus of this approach is on memory (the storage and retrieval of information), a subject that has been of interest for thousands of years. The most widely accepted theory is labelled the “storage theory”, based on the work of Atkinson and Shriffin (1968, as quoted by Huitt, 2003:1). It focuses on how information is stored in memory. The model proposes that information is processed and stored in three stages. This processing is in a serial, discontinuous manner as it moves from one stage to the next (Huitt, 2003:1).

There are several models of this theory explaining how information is received, retained and recalled. These models “propose that the stimulation encountered by the learner is transformed or processed, in a number of ways by internal structures during the period in which the changes identified as learning take place” (Gagne,1985, as quoted by Kehoe, 1999:2).

Individuals receive information from the environment through a sensory receptor: ears, eyes, nose, mouth or sense of touch. The information is a sensation as it enters the body. The sensory receptors constantly receive information and much of this information is discarded immediately. It is critical that the learner concentrates on the information at this stage and further stages in order for the information to move on to the next stage. The sensations that are not discarded is transformed into messages and sent to the working memory. The message is sent forward when the individual pays attention to a stimulus or if the message activates a known pattern (Kehoe, 1999:2).

George Miller’s (1956) theoretical idea of the Information Processing Theory (as quoted by Kehoe, 1999:2) is that information is divided into small “chunk” structures in the working memory (short-term memory). An individual’s working memory can “only hold 5 – 9 chunks of meaningful information” (as quoted by Kehoe, 1999; Huitt, 2003 and Carbonell, 2004). The working memory can only hold a limited amount of information for certain duration of time. Individuals can keep information in the working memory for longer than ten to twenty seconds by rehearsing or repeating. Information that we do remember for a short amount of time goes into the long-term memory. Long-term memory has an unlimited capacity to store knowledge. This is the most essential part of the information processing theory. The information that enters this stage will stay there infinitely. Even though a memory trace in long-term memory is permanent, this does not mean that it can always be retrieved easily. Information that has entered the long-term memory is meaningful to the individual (Kehoe, 1999:3).

There are ways in which instructors can assist in the learning process. By using concrete models and analogies during instruction, teachers actually help the learners to encode information. Another technique used is to state the learning objective before instruction. Learners will then be able to select the important information as the class is being held instead of concentrating on something that is not relevant to the learning objective of the lesson. Gagne (1985, as quoted by Kehoe, 1999:3) purports that the primary effect of providing learners with an expectancy of the learning outcome is to enable them to match their own performance with the class of performance they expect to be correct. Gagne believes that learning is largely dependent on events in the environment with which the individual interacts. Therefore there should be a comfortable working atmosphere, one that does not discriminate and allows for mistakes. The Information Processing Theory (IPT) suggests the importance of feedback and the necessity of making mistakes so that the learner develops problem-solving strategies. A learner with poor encoding and recalling abilities will most likely be a poor problem solver (Kehoe, 1999:3)

Information Processing Theorists reject Piaget's notion of discrete developmental stages. Instead, they believe that children's cognitive processes and abilities develop through steady and gradual trends, for example, they propose that children learn faster, remember more, and handle increasingly more complex tasks as they grow (Flavell, 1985; Gelman & Baillargeon, 1983; Perlmutter, 1984; Siegler, 1986, as quoted by Ormrod, 1995:51-52).

The following principles of the information processing approach can be used to achieve effective learning (Huitt, 2003:8-9):

- Gain the learners' attention
- Bring to mind relevant prior learning
- Point out important information
- Present information in an organised manner
- Show learners how to categorise (chunk) relevant information
- Provide opportunities for learners to elaborate on new information
- Show a learner how to use coding when memorizing lists
- Provide for repetition of learning
- Provide opportunities for maximum learning of fundamental concepts and skills.

3.4.3. Vygotsky L (1896 – 1934)

Vygotsky wrote: "To devise successful methods of instructing school children in acquiring systematic knowledge, it is necessary for us to understand the development of scientific concepts, as contrasted with learning spontaneous concepts, in children's minds" (Bigge & Shermis, 2004:128). Here we see Vygotsky equating the teaching of systematic knowledge with the teaching of "scientific" concepts. He interprets the meaning of "scientific" concepts very broadly to include all generalized systematic knowledge. Since scientific and spontaneous concepts differ from one another in their relation to the child's experience, and in the attitude toward their objectives, they may be expected to follow differing developmental paths from their inception to their final forms.

Learning occurs in children's acquisition of both scientific and spontaneous everyday concepts. Vygotsky (as quoted by Bigge & Shermis, 2004:129) indicates that: "to study the relationship between the development of scientific and that of everyday concepts, we need a yardstick for comparing them." So, the most promising approach to the problem would seem to be the study of scientific concepts, which are real concepts, yet form in our eyes almost in the fashion of artificial concepts.

According to Vygotsky, we can best understand and describe children's cognitive capabilities when we look at two aspects of their development simultaneously. First of all, we can determine the extent to which children can perform tasks independently; this is their actual development level. Secondly, we can determine the extent to which they can perform tasks with the assistance of a more competent individual; this is their level of potential development (Ormrod, 1995:58).

Children can typically do more difficult things in collaboration with adults than they can do on their own. For example, a learner may be able to read more complex prose within a reading group at school than he is likely to read independently at home. A learner who cannot solve problems with remainders on her own begins to learn the correct procedure through interaction with her teacher. The range of tasks that learners cannot yet perform independently, but can perform with the help and guidance of others, is known as the zone of proximal development. It includes learning and problem solving abilities that are just beginning to develop within the child, abilities that are in an immature, embryonic form. Vygotsky proposes that children learn very little from performing tasks they can already do independently. Instead, they develop primarily by attempting tasks they can accomplish only in collaboration with a more competent individual, that is, when they attempt tasks within their Zone of Proximal Development (ZPD) (Ormrod, 1995:59).

For Vygotsky the role of education is to provide children with experiences that are within their respective ZPDs (Zones of Proximal Development) activities that challenge children but which, with sensitive adult guidance, they can accomplish. The teacher's task is to keep each child's learning tasks either centred on, or focused slightly above each respective child's ZPD. Vygosky defined the ZPD as the discrepancy between a child's actual mental age and the level that the child may reach, with assistance, in solving problems. So, when one offers a child a problem that the child is able to handle alone without help, the method of teaching has failed to utilize the conception of the ZPD (Bigge & Shermis, 2004:130).

When adults and other more skilled individuals assist children in performing difficult tasks, they often use a technique called scaffolding to support the children in their efforts. In much the same way as a scaffold provides support for the workers until the building itself is strong enough to support them, an adult guiding a child through a new task may also provide an initial scaffold to support the child's early efforts in that task. As learners become more adept at performing tasks, the adult gradually phases out guidance, and the learners eventually perform those tasks on their own. Therefore, teachers should provide sufficient support (scaffolding) to enable learners to perform challenging tasks successfully and then gradually withdraw the support as they become more skilled (Ormrod, 1995:60).

Within scaffolding, a child is viewed as one who is actively constructing him/herself and his/her environment. The social environment is the necessary scaffolding and framing that permits a child to move forward and continue to build new competencies. This pictured interactional style has repeatedly fostered cognitive growth and has increased children's performance on a wide variety of tasks. A first component of scaffolding is engaging children in interesting, culturally meaningful collaborative problem-solving activities. Participants may consist of either adult-child or child-child groupings. It is important that the children interact with someone while they are trying to reach a goal, both in adult-child and child-child relations. Here, inter-subjectivity is a quality of good scaffolding. This means that two or more participants begin a task with different understandings, but arrive at a constructive shared goal (Bigge & Shermis, 2004:130).

Examples of what we might do in different situations are given by Ormrod (1995:60) depicted from Wood, Bruner and Ross (1976), Diaz, (1990) and Rogoff, (1990):

- Work with a learner to develop a plan for dealing with a new task.
- Demonstrate the proper performance of the task in a way that learners can easily imitate.
- Simplify the tasks.
- Divide a complex task into several smaller, simpler tasks.
- Ask questions that get learners thinking in appropriate ways about the task.
- Keep the learner's attention focused on the relevant aspects of the task.
- Keep learners motivated to complete the task.
- Remind learners what their goal is in performing the task (for example, what a problem solution looks like).

Vygotsky's theory differs from Piaget's in its emphasis on the importance of language to cognition and the crucial role that social, historical, and cultural factors play in the child's acquisition of reasoning and knowledge (Hamilton & Ghatala, 1994:21). Vygotsky's theory asserts that individual development cannot be understood without reference to the social environment, both institutional and interpersonal, in which the child is embedded. He emphasises how much social institutions, tools, and technologies influence the individual's thinking. These socio-cultural devices for cognitive processing are made available to children by people who are more skilled than they are.

The two theories also differ in their view of how social factors affect cognitive development. Piaget focuses on the cognitive conflict that occurs as the individual acts on the physical environment. According to Piaget, the social environment is just another source of experience or information that evokes conflict and adaptation in the child. According to Vygotsky, the socio-cultural environment does not just provide cognitive stimulation that triggers conflict and equilibrium. Rather, it is literally the source of the child's higher cognitive processes. Higher mental processes such as voluntary attention or deliberate remembering are created and sustained through social interaction. The child internalises processes that are first observed and then practiced in social interactions. However, this internalisation is not achieved through simple imitation of observed behaviour. Rather it involves the qualitative transformation of social activities to fit the child's level of comprehension (Hamilton & Ghatala, 1994:254-255).

When looking at information processing in Piaget and Vygotsky's theories, at first glance the two views of cognitive development seem very different. For example, Piaget's theory portrays cognitive development as a sequence of relatively discrete stages, each with its own set of abilities and limitations. In contrast, information-processing theorists describe cognitive development in terms of gradual changes in cognitive processes and meta-cognitive awareness. Vygotsky's approach focuses more on the social conditions that facilitate cognitive development than on changes in children's thinking per se (Ormrod, 1995:63).

Where Vygotsky departs markedly from Piaget, and for which he is most famous, is the use of the "zone of proximal distance" (ZPD), which is a deliberate use of the "social to the individual" in classroom instruction. The ZPD is far less "constructivist" than many believe. The ZPD is a deliberate strategy used by the teacher to engage the learner, connect prior understanding with new content or skills, and may be related to more modern concepts such as advance organisers of Asubel, and scaffolding. Therefore, the ZPD does not ordinarily arise from the mind of the learner, rather it is a device, a social construct, proposed by Vygotsky to conceptualise the apparent range of competence or understanding of a learner at any point, judged by the teacher, so that new content or skills may be introduced. It is conceivable that the motivated learner or group of learners might actually construct their own ZPD for social reasons for the "love" of learning (Marsh II, s.a.: 16).

Despite some major differences among the three perspectives, we also find a number of similarities. Here are seven common themes that run through at least two of the theories, and sometimes through all three:

- Active thinking and learning
- The importance of relating new information to prior knowledge
- Organisation and integration of information
- The importance of social interaction
- The concept of readiness
- Differences between the thought processes of children and adults
- The role of language (Ormrod, 1995:63).

In addition, there is one other important area of similarity. In both Piaget and Vygotsky's views learning is seen as an active rather than passive process, as ultimately each individual reconstructs his/her own understandings in response to environmental stimuli. Regardless of whether the environmental stimulus is teacher scaffolding or direct experience with everyday life phenomena, the learner is still required to access their pre-existing knowledge and beliefs, link these to what is currently being experienced, and modify them if necessary (Palmer, 2005:1855, quoting Driver & Oldham, 1986; Phillips, 19995; Roth, 1994; and Glasersfeld, 1987). Thus according to both views, the reconstruction of meaning requires effort on the part of the learner.

3.4.4. Bruner JW

Two central unifying themes recur in Bruner's writing. The first is that the acquisition of knowledge, whatever its form, is an active process. The second is that one actively constructs one's knowledge by relating incoming information to a previously acquired psychological frame of reference. This frame of reference is a "system of representation" or an "internal model" that gives meaning and organisation to the regularities in experience and permits an individual to go beyond the information. Therefore each person must be regarded as an active participant in the knowledge acquisition process, which selects and transforms information, constructs hypotheses, and alters those hypotheses in light of inconsistent or discrepant evidence (Bigge & Shermis, 2004:137-139). (Note that Bruner uses the concept "active" to convey very much the same notion that cognitive-field interactionists use the concept "interactive" to convey.)

Bruner sees learning as involving three almost simultaneous processes:

1. Acquisition of new information
2. Transformation of knowledge
3. Checking of the pertinence and adequacy of knowledge.

New information may either be a refinement of previous knowledge or be of such a nature that it runs counter to a person's previous information. In transformation of knowledge, one manipulates knowledge to make it fit new tasks. Transformation, then, entails the way we deal with information by converting it into another form. We check the pertinence and adequacy of knowledge or information by evaluating whether the way we manipulate it is adequate to the task at hand. Such evaluation often involves judgements of the plausibility of knowledge. Bruner labels his view of learning or cognitive growth as "instrumental conceptualism." This view centres on two tenets concerning the nature of the knowing process:

1. One's knowledge of the world is based on one's constructed models of reality.
2. Such models are first adopted from one's culture, then, adapted to one's individual use.

A person's perception of an event, then, is essentially a constructive process within which that person infers a hypothesis by relating his/her sense data to his/her model of the world and then checks his/her hypothesis against additional properties of the event. Thus a perceiver is viewed as not a passive, reactive organism, but as a person who interactively selects information, forms perceptual hypotheses, and on occasion distorts the environmental input in the interest of reducing surprise and attaining valued goals (Bigge & Shermis, 2004:138).

Bruner does not view mental growth as a gradual accretion, either of associations or stimulus-response connections, or of means-end–readiness, or for that matter of anything else. It appears to be much more like a staircase with rather sharp risers, more a matter of spurts and rests. The spurts ahead in growth seem to be touched off when certain capacities begin to develop (Bigge & Shermis, 2004:139).

Before Vygotsky's notion of the zone of proximal development was widely appreciated in the West, Bruner and Wood and their associates introduced the closely related concept of scaffolding, a process through which an adult provides support to a child learning to master a problem (Bruner, 1978; Wood, Bruner, & Ross, 1976; Wood & Middleton, 1975, as quoted by Hamilton & Ghatala, 1994:269). In scaffolding adults direct those elements of the tasks that are initially beyond the capacity of the child. This makes it possible for the child to participate in strategic activities without really understanding completely (Hamilton & Ghatala, 1994:269). Bruner's research emphasises the role of the teacher. It was not enough simply to let children think, work, and play on their own. They need someone to "scaffold" their learning, to lead them on to higher levels. One way of doing this is to help children focus on the key concepts of what they are learning, and then revisit these concepts again and again. This process is likened to a spiral, coming back on itself, but at higher levels (Fisher, 1995:12).

Wood, Bruner and Ross (1976) (as quoted by Hamilton & Ghatala, 1994:270) list six scaffolding functions that may be carried out by adults who are assisting children:

1 *Recruitment*. The adult must first engage the child's interest in and adherence to the requirements of the task. The younger the child, the more importance this function assumes.
2 *Reduction in degrees of freedom*. This involves simplifying the task by reducing it to subtasks. The child is allowed to concentrate upon subroutines that he can manage while the adult fills in the rest.
3 *Direction maintenance*. This involves keeping the goal of the task before the child who may tend to "wander" to other aims. It also involves displaying enthusiasm and compassion to keep the child motivated, as well as encouraging the child to move beyond those aspects of the task he has already mastered to risk the next step.
4 *Marking critical features*. The adult, by various means, accentuates certain features of the task that are relevant.
5 *Frustration control*. The adult helps the child overcome frustration by "face-saving" for errors or by exploiting the child's "wish to please".
6 *Demonstration*. The adult's role involves considerably more than simply performing solutions in the presence of the child. It often involves "imitating" in idealized form a solution tried (or assumed to be tried) by the child. This gives the child the opportunity to "imitate" it back in more appropriate form. Children apparently imitate only acts they can already do fairly well.

Bruner, (1960, 1961, 1966); Kuslan and Stone, (1972); Massialas and Zevin, (1983) (as quoted by Ormrod, 1995:443) provide additional arguments in favour of discovery learning. For one thing, learners can better understand and appreciate the ways in which the world is predictable (as reflected in basic principles of science, mathematics, and various other disciplines) when they actually observe such principles in action. In other words, if a learner may learn something as well as hear or read about it, he/she can encode that information in the long-term memory visually as well as verbally. Finally, if learners learn information meaningfully and store it in more than one form, they are more likely to retrieve that information in appropriate situations, for example, when they need it to solve a problem (Ormrod, 1995:443-444).

3.4.5. Posner

Learning is a rational activity. That is, learning means fundamentally coming to comprehend and accept ideas because they are intelligible and rational. It is a kind of enquiry. The learner must make his/her judgement on the basis of available evidence. It does not, of course, follow that motivational or affective variables are unimportant to the learning process. The claim that learning is a rational activity focuses attention on what learning is and not what learning depends on. Learning is concerned with ideas, their structure and evidence for their existence. It is not simply the acquisition of a set of behaviours. It is best viewed as a process of conceptual change (Postner, Strike, Hewson & Gertzog, 1982:211).

Postner et al. (1982) believe that there are analogous patterns of conceptual change in learning. Sometimes learners use existing concepts to deal with new phenomena. This variant of the first phase of conceptual change they call assimilation. Often, however, the learners' current concepts are inadequate to allow him to grasp a new phenomenon successfully. Then the learner must replace or reorganise his central concepts. This radical form of conceptual change they call accommodation (Postner, 1982:211). Based on the traditional constructivist framework, conceptual change is not a matter of replacing bad generalizations with good ones. Instead, it's partly a matter of tweaking those generalizations into a better-defined, integrated, coherent structure (Jabot, 2002:4).

It is important to note that a person's central concepts are the vehicle whereby a given range of phenomena becomes intelligible. Such concepts can be linked to prior experience, images, or models that make them appear intuitively obvious and which make competing concepts seem not just wrong, but virtually unintelligible (Postner, et al., 1982:211-212).

Postner and others propose four conditions for conceptual change that should be recognized as a person formulates his instructional theory (Trowbridge et al., 2004:23). These four conditions seem to express conditions that are common to most cases of accommodation.

- *There must be dissatisfaction with existing conceptions*. Scientists and learners are unlikely to make major changes in their concepts until they believe that less radical changes will not work. Thus, before accommodation will occur, it is reasonable to suppose that an individual must have collected a store of unsolved puzzles or anomalies and lost faith in the capacity of his current concepts to solve these problems.
- *A new conception must be intelligible*. The individual must be able to grasp that his experience can be structured sufficiently by a new concept in order to explore the possibilities inherent in it. Writers often stress the importance of analogies and metaphors in lending initial meaning and intelligibility to new concepts.
- *A new conception must appear initially plausible*. Any new concept adopted must at least appear to have the capacity to solve the problems generated by its predecessors. Otherwise it will not appear a plausible choice. Plausibility is also a result of consistency of the concepts with other knowledge. A new idea in, say, astronomy, is less likely to be

accepted if it is inconsistent with current physical knowledge or if it simply has no clear physical account.

- *A new concept should suggest the possibility of a fruitful research program*. It should have the potential to be extended, to open up new areas of inquiry (Postner, 1982:214).

The notion of accommodation relies on a learner's previous knowledge and whether the new concept is within the learners' reach. The new concepts must also be challenging. Taking Piaget's notion of learning into consideration, Postner regards learning as an interaction with the environment. This notion has been generally supported and, in fact, was the foundation for contemporary constructivist explanations of learners' conceptual understanding. The theoretical basis for constructivist research comes from several sources, including David Ausubel. L.S. Vygotsky is a second important source for constructivism. He wrote of learner conceptions and teacher conceptions, and how learners and teachers might use similar words to describe concepts, yet have different personal interpretations of those concepts. His work implies that science instruction should take into account the differences between teacher and learner conceptions and should provide a great deal of learner-learner interaction so that learners can develop concepts from those whose understandings and interpretations are closer to their own. Constructivist research also suggests other strategies to promote conceptual change (Trowbridge et al., 2004:23) as will be discussed in the following paragraphs.

3.5 Alternative theory of knowing

Thornton (1987, as quoted by Trumper, 2003:649) claims on the basis of many studies that traditional science instruction in schools has shown to be ineffective in altering learner misconceptions and simplistic understanding (Trumper, 2003:649). Schools are expected to transmit knowledge to younger generations. They are, however, also increasingly criticised for distributing so-called inert knowledge, i.e. knowledge that is accessed only in a restricted set of contexts even though it is applicable to a wide variety of domains. The causes of limited knowledge transfer are mostly attributed to the lack of resources for learning in schools situations. In contrast, instructional procedures that result in learning in the sense of being able to recall relevant information provide no guarantee that people will spontaneously use it later (Vanderstraeten & Biesta, 1998:1).

In classrooms, activities are such that the teacher talks most of the time, the learner is required to exert a great deal of attention (a difficult task), comprehend terms the teacher uses (a more difficult task), impose order on the incoming temporal stream of information (an often impossible task), make judgements about the quality and significance of the information (an unrealistic task), attempt to write down as much as possible (a torturous task), and memorise for later reproduction the information presumed to be important (for most learners, the conceivable task). The learner must also sit in uncomfortable chairs and do this continually for five to six hours a day, five days a week. There is little opportunity, beyond memorization, to create and act upon new knowledge (Marsh II, s.a.:4).

Accommodation of concepts is quite discreet even at the university level. Learners continue to hold fundamental misunderstandings of the world around them. Science learning stays within the schools' classroom context and has no effect on their thinking about the large physical world. The ineffectiveness of conceptualisation is neither dependent on the apparent skills of the teacher, nor on whether learners have taken Physical Sciences in FET schools. The worst is the presentation of collections of unrelated science facts and vocabulary, with no attempt to develop critical thinking or problem-solving skills. Not only do learners not have an opportunity to form their own ideas, they rarely get a chance to work in any substantial way at applying the new ideas to the world around them (Trumper, 2003:649).

Traditional science teaching do not make strong connections with the everyday experience of the learners, and the "understandings" that serve them well within united domains do not help them comprehend the general principles underlying deeper scientific knowledge. This traditional teaching approach tends to suppose that most learners have no scientific knowledge before starting a new topic, but if they did have prior knowledge they would have little difficulty in replacing their (deficient) understanding by another (better) understanding (Trumper, 2003:649).

"Authentic learning", acquiring knowledge in the contexts that (will) give this knowledge its meaning, is now presented as an alternative in the following paragraphs. Underpinning these reform proposals is not only a (growing) concern with efficiency, but also a new epistemological theory, labelled as constructivism (Vanderstraeten & Biesta, 1998:1).

3.5.1 Constructivism

The word "construct" and "construction" have been in use for centuries, of course. However, "constructivism" is a relatively new word. It is appearing with an accelerating frequency in the titles of books and articles in psychology. The verb "to construct" comes from the Latin word *construere,* which means to arrange or give structure. Ongoing structuring (organizing) processes are the conceptual heart of constructivism. Among the earliest recorded proponents of some form of constructivism are Leo Tzu (6th century BC), Buddha (560 – 477 BC), and the philosopher of endless change, Heraclitus (540 – 475 BC). In western cultures, constructivists often trace their intellectual genealogy to Giambattista Vico (1668 – 1744), Immanuel Kant (1724 – 1804), Arthur Schopenhauer (1788 – 1860), and Hans Vaihinger (1852 – 1933). Vico emphasized the role of fantasy and myth in human adaptation (Mahoney, 2004:2). One of Vico's basic ideas is that epistemic agents can know nothing but the cognitive structures they themselves have put together. "To know" means "to know how to make." He substantiates this notion by arguing that one knows a thing only when one can explain it. Such explanations are for others to understand and to use (Yager, 1991:44).

Kant (1724 – 1804) emphasized the role of patterns in our thinking, and he regarded ideas as regulative principles in our experiencing. His "categories" are predecessors of what is now called "constructs" and "schema." William James also explored several constructivist themes, and he and several colleagues carried the curiosity of constructivism across the transition from the 19th to the 20th centuries (Mahoney, 2004:2).

Constructivism continued to grow throughout the second half of the 19th century, and it is now the focus of numerous books and international journals. The rapidity of its growth sometimes makes constructivism seem like a recent development, when in fact it has been emerging for centuries. It is clearly more than a parochial endeavour. Five basic themes pervade the diversity of theories expressing constructivism. These themes are 1) active agency, 2) order, 3) self, 4) social-symbolic relatedness, and 5) lifespan development (Mahoney, 2004:4)

With different language and terminological preferences, constructivists:

- Firstly propose that human experiencing involves continuous active interaction. This distinguishes constructivism from forms of determinism that cast humans as passive pawns in the play of large forces.
- Secondly contend that much human activity is devoted to ordering processes – the organisational patterning of experience by means of tacit, emotional meaning-making processes.
- Thirdly argue that the organisation of personal activity is fundamentally self-referent or recursive. This makes the body a fulcrum of experiencing, and it honours deep phenomenological sense of selfhood or personal identity. However, the self is not an isolated island of Cartesian mentation. Persons exist and grow in living webs of relationships.
- Fourthly, commonly feel that individuals cannot be understood apart from their organic embeddedness in social and symbolic systems.
- Finally, contend that all of the active, meaningful, and socially embedded self-organisation reflects an ongoing developmental flow in which dynamic dialectical tensions are essential. Order and disorder co-exist in lifelong quests for dynamic balance that is never quite achieved.

Together, then, these five themes convey a constructive view of human experience as one that emphasises meaningful action of developing oneself in a complex and unfolding relationships. One can easily see the spectrum of contributions that make up constructivism. They range from Taoism and the process philosophy of Heraclitus to the personal, social, and narrative emphases of contemporary constructivists like Bandura, Bruner, and Gergen (Mahoney, 2004:4-5).

Though rooted in Piagetian research, constructivism is an avenue of research pertaining to teaching and learning that departed from the neo-Piagetian mainstream years ago and has continued on a distinct path of development. The departure became evident by the late seventies, clearly marked by two publications, Novak (1977) and Driver and Easley (1978). Constructivists do not see learning as knowledge written on, or transplanted to a person's mind as if the mind were a blank slate waiting to be written on or an empty gallery waiting to be filled (Cobern, 1993:51). A constructivist believes the following: Learners don't walk into the classroom as blank slates ready to be filled with knowledge. Instead, learners construct a new understanding, and their prior knowledge plays an important role in the construction of such knowledge (Jabot, 2002:4).

The most outspoken pioneer of a constructivist approach has been Ernst von Glasersfeld, whose 'radical constructivism' is still at the centre of debate. Elaborating on the works of Jean Piaget, von Glasersfeld particularly focuses on individual self-regulation and abstraction. According to von Glasersfeld, 'authentic' learning depends on seeing a problem as "one's own problem", as an obstacle that obstructs one's progress towards a goal. The farthest removed from this individualistic focus seems to be the socio-cultural approach that originated with Ljev Vygotskij (Refer to paragraph 3.2.3). It stresses the socially and culturally situated nature of mental activities, defines learning as getting acquainted with cultural practices, their particular exigencies, limits and possibilities (Vanderstraeten & Biesta, 1998:2).

One should further clarify the basic intuition of a constructivist theory of knowledge in order to point out its relevance and consequences. The hard core of constructivism concerns the reconcilability of, on the one hand, *plurality* of knowledge and, on the other, its reference to reality. If knowledge is no representation of reality but one's own construction, how does it have a hold in realty? How is, in other words, the existence of plural realities to be accounted for? To be sure (and against often raised objections in philosophical discussions), constructivism does not entail a relativist, anti-realist position. Neither does it recur to the sceptic, nor do "solipsistic" doubt about whether there is any external world. In a way, the multitude of empirical research based on a constructivist perspective should already be convincing evidence for its realism (Vanderstraeten & Biesta, 1998:3).

3.5.2 Constructivism as a theory

Given the problems in science teaching, it should be fruitful to alter the way most science courses are taught: to begin with what learners know, continue with what they can learn by arranging their interaction with the physical world around them, and connect this learning to the underlying principles of scientific knowledge. An instructional practice that has emerged over the last two decades begins with what is commonly termed the personal constructivist model of learning, or simply personal constructivism. A personal constructivism model of learning assumes the existence of learners' conceptual schemata and the active application of these in responding to and making sense of new situations (Trumper, 2003:650).

Constructivism is basically a theory based on observation and scientific study about how people learn. It says that people construct their own understanding and knowledge of the world through experiencing phenomena and reflecting on those experiences. When we encounter something new, we have to reconcile it with our previous ideas and experiences, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. In order to do this, we must ask questions, explore, and assess what we know (Concept to Classroom, 2004).

According to Sherman (1995, as quoted by Hsiao, 1996:1), constructivism claims that knowledge is not "about" the world, but rather "constitutive" of the world. Knowledge is not a fixed object. It is constructed by an individual through his/her own experience of that object. Its objective is to create learning communities that are more closely related to the collaborative practice of the real world. In an authentic environment, learners assume the responsibilities of their own learning, they have to develop meta-cognitive abilities to monitor and direct their own learning and performance (Hsiao, 1996:1).

Using constructive alternativism philosophy to develop the personal construct theory, Kelly (1955, as quoted by Adams et al. 1999:958) came up with this fundamental postulate: "A person's process are psychologically channelled by the ways in which he anticipates events." This can be interpreted as: "A person lives his life by reaching out for what comes next and the only channels he has for reaching are the personal constructions he is able to place upon what may actually be happening." Constructs are defined by the interweaving of the past, present, and future; events give definition to constructs and constructs give meaning to events. The implication is that reflection on an experience, which in essence anticipates the future event, can result in a reconstructing of a construct (Adams & Krockover, 1999:958).

The research literature on memories identifies two major types of memory: semantic and episodic. Episodic memory “consists of personal experiences stored as information about episodes or events,” while semantic memory “consists of general knowledge about the world that is organised into schemes or categories and is context-free; its retrieval does not usually involve the experience of remembering” (Ben-Peretz, 1995:8, as quoted by Adams & Krockover, 1999:958). They continue to quote Cohen (1989), stating that these “two forms of knowledge are not separate compartmentalized structures but are in an interactive and interdependent relationship,” where semantic knowledge is derived from episodic memory through abstraction and generalization. This can be summarised by quoting Carter and Doyle (1987) who state in Adams and Krockover, (1999:958) that: “A central premise of cognitive science is that comprehension is a constructive process . . . . Meaning does not result from the reception or rehearsal of information. Rather understanding involves an active construction of a cognitive representation of events or concepts and their relationships in a specific context”.

In the classroom, the constructivist view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging learners to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding changes. The teacher makes sure he/she understands the learners’ pre-existing conceptions, and guides the activity to address them and then build on them (Concept to Classroom, 2004).

The constructivist approach to learning emphasises authentic, challenging projects that include learners, teachers and experts in the learning community (Hsiao, 1996:1). Constructivist teachers encourage learners to constantly assess how the activity helps them gain understanding. By questioning themselves and their strategies, learners in the constructivist class ideally become “expert learners.” This gives them ever-broadening tools to keep learning. With a well-planned classroom environment, the learners learn how to learn.

Indeed, constructivists do not consider knowledge to be an objective representation of an observer-independent world. For them, knowledge refers to conceptual structures that epistemic agents consider viable. Constructivists are like pragmatists in that they do not accept the idea of truths as correspondence with reality. Modern science does not give us truth; it offers a way for us to interpret events of nature and to cope with the world (Yager, 1991:44).

3.5.3 Constructivist approach to science learning

Recent research in science education has been dominated by a constructivist view of learning. According to this view, learners do not passively absorb information. Meaningful learning involves the active creation and modification of knowledge structures (Carey, 1985 as quoted by Palmer, 2005:1854). When learners learn about science they use their existing knowledge, beliefs, interests, and goals to interpret any new information, and this may result in their ideas becoming modified or revised.

After analysing the features of many of the varieties of constructivism that have been proposed, including the views of authors such as von Glasersfeld, Kant, Kuhn, Piaget, and Dewey, Phillips (quoted by Palmer, 2005:1854), one finds that the variants differ according to the extent to which they focus on knowledge construction within individuals rather than knowledge construction within disciplines, and they also vary in the extent to which they propose that knowledge is either made or discovered.

The cognitive constructivist viewpoint developed from the ideas of Jean Piaget (as indicated in paragraph 3.3 above) emphasizes the importance of the cognitive processes that occur within individuals. According to this view, individuals interpret experiences in order to make meaning and develop their own personal understandings. Cognitive constructivism therefore emphasises the personal construction of knowledge. According to this view, teachers have the relatively peripheral role of providing suitable experiences that will facilitate learning (Palmer, 2005:1855).

On the other hand, “social constructivism”, developed from the ideas of Lev Vygotsky, emphasizes the importance of society, culture, and language (Lemke, 2001; and Vygotsky, 1978, as quoted by Palmer, 2005:1855). According to this perspective, knowledge is socially constructed and learning takes place in particular social and cultural contexts. Social interaction provides children with ways of interpreting the physical and social world, and learners thus become acculturated into ways of thinking that are common practice in that specific community. Much learning takes place when children interact with more competent individuals such as adults and teachers. Through a process of scaffolding, a teacher can gradually guide learners to develop their knowledge and skills while making connections with learners’ existing schemes. According to this view, teachers have a central role in providing guidance and support to learners (Palmer, 2005:1855).

Therefore, in the social constructivist perspective, referred to in Vygotsky’s work (1978), thinking processes and knowledge development are seen as the consequence of personal interactions in social contexts and appropriation of socially constructed knowledge (Trumper, 2003:653).

Cognitive psychologists have examined our traditional approach to teaching and have concluded that pedagogy has been dominated by the behaviourist model: In a behaviourist approach, the teacher's task consists of providing a set of stimuli and reinforcements that are likely to get learners to emit an appropriate response. If the goal is to get learners to replicate certain behaviour, this model works well, but if understanding, synthesis, eventual application, and the ability to use information are our goal in education, a behaviourist approach is not the appropriate approach. It is not surprising that behaviourist training rarely produces understanding, given the fact that there is no place in the model for it. The constructivist model of learning provides greater emphasis on understanding, forming relationships between concepts, relating new learning to schema already present in the brain, and developing applications of new knowledge to events and problems that the learner encounters (Trowbridge et al. 2004:156).

Hewson and Hewson (1984, as quoted by Trumper, 2003:651) state that for a conceptual change to take place, instruction should reduce the plausibility of the existing conceptions by illustrating how those conceptions are not satisfactory, and by then encouraging the acceptability of the new conception. The motivation for change arises when the learner recognizes that the new conception is more fruitful than the old ones. When a learner gets a new piece of information, the learner compares the information to the knowledge and understanding he/she already has, and one of three things can occur:

- The new information matches up with his previous knowledge pretty well (it's consonant with the previous knowledge), so the learner adds it to his/her understanding. It may take some work, but it's just a matter of finding the right fit, as with puzzle pieces.
- The information does not match the previous knowledge (it's dissonant). The learner has to change his/her previous understanding to find a fit for the information. This can be a harder work.
- The information doesn't match a previous knowledge, and it is ignored. The learner may just not absorb rejected bits of information, or they may float around, waiting for the day when the learner understanding has developed and permits a fit.

Use of teaching strategies that influence conceptual change could positively affect learner performance. A personal constructivist approach is based on a view of the learner as active and purposive in the learning process and involved in bringing their prior knowledge to construct meanings in new situations. Such teaching requires a thorough understanding of subject-matter knowledge, including knowledge of learners' likely preconceptions and representations of subject matter that learners can grasp. Teachers must be able to identify learners' misconceptions and know how to challenge them (Trumper, 2003:651).

The concept of learning demand helps focus the teacher's attention on the personal steps required for sense-making in the learning of science, and further, provides a starting point for identifying the nature of any difficulties that the learner is likely to experience in coming to accept the scientific point of view (Leach & Scott, 2000:45).

Leach and Scott (2000:45) summarise science learning by saying the following:

- Learning science involves being introduced to the new ways of talking and thinking in the scientific community, which are based on particular scientific concepts and modes of explaining;
- Learners already have everyday ways of thinking (alternative conceptions) about the phenomena, and detailed accounts of these alternative conceptions now exist in a number of topic areas;
- Alternative conceptions continually reinforced in day-to-day talk are often different to the scientific view; as such alternative conceptions can act as a 'barrier' to science learning;
- Science learning originates in social situations, and language is central to teaching and learning science. Language provides the means by which new ideas are first introduced and rehearsed and also the 'tools' for pupil thinking. The 'talk of science' provides the conceptual tools for 'thinking about science.'

Given this scenario, Trumper (2003) came up with the key aspects of personal constructivism that should influence the material for developing learners' understanding. He expressed them as "the teacher's need." For science learning to be effective, the teacher needs to:

1. have knowledge of learners' existing understanding in the targeted conceptual areas and use this as a starting point for the design of appropriate teaching materials;
2. provide experiences that will help learners confront discrepancies between their own incorrect or limited views and accepted scientific views;
3. verify that learners do in fact adhere to correct scientific views.

Consequently, general teaching strategies must incorporate both instructional methodology and content and induce learners to make changes in their beliefs of how the world works (Dykstra et al., 1992, as quoted by Trumper, 2003:651). Although these strategies require learners to experience phenomena that will make changes in their beliefs, they rely upon the development of a supportive climate (Trumper, 2003:651).

Trumper (2003) summarised the principles that may get learners to change their deeply held ideas as follows:

1. Go from the concrete to the abstract
2. Put whatever is new into a known and understood context
3. Make learners articulate what they have seen, done, and understood in their own words
4. First get them to understand the situation, and then make a prediction
5. Finally, they have to see the conflict between their prediction and their observation
6. Explaining a concept to someone often has little effect on developing his or her thinking or understanding of that concept. Learning includes doing, but "hands-on" activity does not suffice. It must be "brain-on" – that is, a cognitive activity that leads to the reconstruction of currently held concepts or the emergence of new ones.
7. "Constructive" activities in which learners feel they are in control are much more effective than activities in which the learners are shown results, no matter how eloquently or lucidly the results are presented.

Accordingly, constructivism implies that learners

*"……..*must be given *opportunities to experience what they are to learn in a direct way and the time to think and make sense of what they are learning. Laboratory appeals as a way of allowing learners to learn with understanding and, at the same time, engage in the process of constructing knowledge by doing science"* (Tobin 1990a, as quoted by Trumper, 2003:652).

Hodson (1993:109, as quoted by Trumper, 2003:652) summarised a series of teaching steps that are intended to bring about conceptual development and modification in learners:

I. Making children's own ideas explicit through writing and thorough discussion with other children and the teacher. After all, constructivism is having a conversation. This conversation can happen anywhere as long as the people involved know their views are valued, and can handle differing views (Shiland, 2002:2).
II. Exploring the implications of those ideas.
III. Matching and testing ideas against own experience and the experience of others.
IV. Criticising the ideas of others. Subjecting one's own ideas to criticism.
 a) At this point the teacher should challenge children to find evidence and support for their ideas. Critical interpretation of evidence is the basis for maintaining a particular theoretical view in science.
V. Using theoretical ideas to explain observation, phenomena, and events.
VI. Applying theoretical ideas to new situations.

VII. Modifying and refining ideas to ensure a better match with "reality".

VIII. Making predictions. Subjecting theories and predictions to critical tests in the search for support, refutation, and refinement.

*At this point the teacher should begin activities designed to affect a shift in understanding. For example, demonstrate the event. Present learners with an opportunity to observe results that contradict their normal expectancy. Prompt learners to investigate the event and provide them with the opportunity to confront the problem being raised (Llewellyn, 2002:5).

IX. Introduction of experiences to challenge and contradict children's existing views. Llewellyn (2002:5) emphasises that learners should be encouraged to test the event or discrepancy by forming hypothesis. The teacher should provide guidance without giving away the answer or giving an explanation.

X. Encouraging the generation of alternative conceptual frameworks and explanations by means of "brainstorming" activities. Llewellyn (2002:5) indicates that learners should be allowed time to share the results of their enquiries, after which they should apply the concept being studied to the questions being investigated. After all, "Discovery is the ability to be puzzled by simple things". Noam Chomsky as quoted by Shiland, 2002:2.

XI. Introduction of the "official" explanatory framework as one of the alternatives – if necessary.

XII. Exploration and testing of all alternatives (repeating steps i - viii).

XIII. Comparison, judgement, and selection of the alternative that proves most acceptable to the learning group (including the teacher); i.e., reaching consensus – a key step in the practice of science.

The above-mentioned constructivist implications are summarised by Novodvorsky (1997:243) in a nutshell as follows:

- Learners actively hypothesise, check, and possibly change their ideas as they interact with phenomena. Learners are actively engaged in proposing ideas, asking questions, and generating explanations. They are observed as they are **modifying or refining** their ideas and checking their hypothesis.
- Learners actively engage with others in an attempt to understand and interpret phenomena.
- Learners make personal sense of ways of viewing the world.
- Learners are easily introduced into the practices of the scientific community.
- Learners generate links between existing knowledge and new phenomena.

The above-noted components of constructivist learning are meant as a guide for engaging learners to construct their own knowledge. Here it is important to note that when learners construct their own knowledge, they are not at the same point in that process simultaneously. Thus, the components are key to observing individual learners. Taken in total, these components describe a classroom environment, centred on the teacher's and learners' constructivist philosophy, rather than a particular technique (Novodvorksy, 1997:243).

An environment where learners work with others on common, truly problem-oriented tasks is central to the learning settings proposed. When learners are working together on problems, new knowledge is first constructed collaboratively in the shared problem space, after which the learner consequently appropriates it, that is, individually constructs his/her own representations (Newman et al., 1989 & Rogoff, 1990, as quoted by Trumper, 2003:652). At the same time, learners' individual constructions of meaning take place when their ideas are evaluated, explored, and supported in a social setting, such as that provided by the laboratory, with each learner having the opportunity to restructure his or her ideas through talking and listening. Through social interactions learners become aware of others' ideas, look for reconfirmation of their own thoughts, and reinforce or reject their personal constructions (Trumper, 2003:652).

Posner et al. (1982), as quoted by Leach & Scott, 2000:43) identify the need for new knowledge to be 'intelligible', 'plausible' and potentially 'fruitful' for the learner during knowledge acquisition if learning, or conceptual change, is to occur. This can be illustrated by using the example of an air pressure explanation for drinking through a straw. The learning demand for an individual learner might involve: using the concept of 'air pressure' rather than 'sucking' (a conceptual demand); coming to accept that air is a substantial material that can exert large pressure (an ontological demand); and appreciating that the concept of air pressure is generalisable and can therefore be used to explain a whole range of different phenomena (an epistemological demand). It might well be the case that the learner can understand the air pressure explanation (it is intelligible), but they just can't believe it or it doesn't seem to make sense (it isn't plausible). In this case, learning the scientific view involves the learner in making significant changes to their fundamental assumptions about the nature of the whole world (Leach & Scott, 2000:45).

In any case, knowledge acquisition and conceptual change take place through a process of formulation, reformulation, and reinterpretation of knowledge in which the learner is continuously evaluating a concept's significance, comparing different points of view, and testing the concept's validity. The learner is an active constructor of his/her own knowledge, and the process of knowledge acquisition is greatly assisted by interaction with peers, and in particular with a teacher acting at the zone of proximal development (Vygotsky, 1978, as quoted by Trumper, 2003:653).

3.6 Conclusion

This chapter outlined the historical development of learning theories that are related to or led to the constructivist approach to science teaching. One will realise that constructivism, like OBE, is learner-centred. It is very important that teachers should understand the concept of learning and they should be able to achieve the objectives of learning. Teaching is always aimed at attaining the objectives or outcomes. In constructivism, outcomes are the end products of teaching, just as in OBE.

Teachers' understanding of OBE is utmost important for its actualisation. Everything teachers do (Bigge & Shermis, 2004:4) is coloured by the psychological theory they hold. Consequently, teachers who do not make use of a systematic body of theory in their day-by-day decisions are behaving blindly; little evidence of long-range rationale, purpose, or plan is observable in their teaching. Thus, teachers without a string theoretical orientation inescapably make little more than busy-work assignments. Some teachers operate in this way and use only a hodgepodge of methods without theoretical orientation. Teachers who are well grounded in scientific psychology – in contrast to "folklore psychology" – have a basis for making decisions that are much more likely to lead to effectual results in classrooms (Bigge & Shermis, 2004:4).

Against the background of the discussion on the theories of learning and its implications for Outcomes-Based learning, the next chapter discusses the Outcomes-Based Education and the National Curriculum Statement.

CHAPTER 4

OUTCOMES-BASED EDUCATION AND THE NATIONAL CURRICULUM STATEMENT

4.1 Introduction

At the beginning of the 1990s, education in South Africa was in turmoil and experienced a major crisis. Adding to the crisis were problems such as major inequalities in South African society where the majority of people were marginalised and forced to live in a disenfranchised society. Educational change was required to provide equity in terms of educational provision and to promote a more balanced view of South African society. The new democratic African National Congress government has striven to root out Apartheid education and to create a new vision of empowered citizens for South Africa. Against this background, Outcomes-Based Education (OBE) was chosen in 1997 as the most likely educational model to address the crisis in South African education; the most likely system to operate at all educational levels; and the most likely model to address the issue of quality (and inequality) in South African education. This approach or model was chosen not only to emancipate learners and teachers from a content-based mode of operation, but also to respond to international trends in educational development (Botha, 2002:3).

It is against this background that this chapter explores some of the basic principles of Outcomes-Based Education and relates them to constructivism and the National Curriculum Statement. It is intended to help teachers understand the objectives of Curriculum 2005 and how they can translate the theory and philosophy of OBE, Constructivism, and National Curriculum Statement into practical action in their instructional planning, teaching and assessment of learners' learning.

4.2 Curriculum 2005

In March 1997 the Education Minister announced in the British parliament the launch of Curriculum 2005 – "our new national curriculum for the twenty first century."

In his official announcement, Professor Bengu, the then Minister of Education in South Africa, gave amongst others the following reasons for the new approach:

- "The goal of the review process was to phase in, with effect from 1998, a new curriculum that is based on the ideal of lifelong learning for all South Africans."
- "Essentially, the new curriculum will effect a shift from one which has been content-based to one which is based on outcomes" (DoE, 1997:1).

This was followed by a great fanfare, culminating in the release of 2005 multi-coloured balloons in Cape Town on 24 March 1997 (Jansen, 1998:321). After the program was accepted by the government as an answer to South Africa's education problems, the task of the training teachers and student teachers and informing parents and other stakeholders about what OBE is became an important task (Vermeulen, 1997:6).

Leading up to this event, schools and their allies had been repeatedly warned by the National Department of Education that January 1998 was an 'absolute non-negotiable' date for the implementation of what has only recently become known as OBE. Within months, an explosion of curriculum activity thundered across South Africa as committees of departmental officials, curriculum developers, subject specialists, teachers, lecturers, trade union and business representatives and a good representation of foreign 'observers' from Scotland and Australia attempted to translate OBE into workable units of information for teaching and learning so that it could be ready for first phase implementation in 1998 (Jansen, 1998:321-322).

The difficulties of reconstruction and social renewal are great as citizens of the Republic of South Africa are learning in our new democracy, as are the levels of commitment demanded when it comes to challenging deep-seated and entrenched sensibilities about the nature of the world and its organisation. During Apartheid, education was used not only to achieve social separation but, insofar as it was built around a social philosophy, it was also the legitimating arena for white supremacy and for the complex system of racial and cultural ordering that evolved around it. Within the old order's traditional educational institutions, the hidden and explicit curricula were configured to produce, reproduce, and validate racial separation and hierarchy. Presumptions of European superiority and African inferiority within this canon were commonplace. Indeed, they were established as modern truths about human progress and development. These truths provided the ideological foundations upon which Apartheid education was built (Soudien & Baxen, 1997:449).

Jansen (1999, as quoted by Howie, 2001:43) indicates that during the Apartheid period, the curriculum was very prescriptive, content heavy, detailed, and authoritarian, with little space for teacher initiative. Teaching was primarily chalk and talk, with a strong dependence on textbooks and rote learning. In an attempt to depart from this status quo, the government introduced C2005, which was a huge and ambitious enterprise to radically reform education. The underlying principle of this curriculum reform was that of Outcomes-Based Education (Howie, 2001:43).

The Latin origins of the word "curriculum" lie in the word "currere", which means "to run", thus "curriculum" implies a relatively fixed "track", "route" or "racecourse" (learning content, learning opportunities, activities and evaluation) that must be covered (mastered) by the participant (learner) in order to reach the winning-post (learning result) (Vermeulen, 1997:6) anticipated by the society or department (government). Fraser et al. (1993:92, as quoted by Vermeulen, 1997:7) define curriculum as the interrelated totality of aims; learning-content; teaching and learning activities, opportunities and experiences, and evaluation procedures that guide and implement the didactic activities in a planned and justified manner.

Curriculum 2005 was announced by the Department of Education as an Outcomes-Based curriculum, developed in First World countries like the Netherlands, Canada, Australia and the USA, to replace the then existing (e.g. the 1995 Interim Core Syllabuses) content based curriculum (Claassen, 1998:34; Pretorius, 1998:v and, Bertrams et al., 1997:1 as quoted by Vermeulen, 1997:6). Curriculum 2005 provides the vision of what learning and teaching should be according to society's goals. It incorporates what is to be learned, processes of learning, teaching and assessment, relationships, power and authority in the system and in schools (Howie, 2001:43).

4.3 OBE and its origin

An Outcomes-Based approach to education dates back some 500 years to the craft guild of the Middle Ages in Europe in the form of apprenticeship training models, and there are many examples still in place today (Spady, 1996, as quoted by Butler, 2003:5). McAvoy (1985:28, as quoted by Malan, 2000:23) traced the documented use of objectives in education back as far as 1860 when Spencer in Britain formulated objectives according to a classification of human activities. In 1924 Herbart in Germany stressed the importance of lesson planning and stating objectives to guide teaching activities.

In 1949 Tyler gave further impetus to the objectives oriented movement by stressing the importance of objectives in curriculum design and teaching practices. He listed four questions as the basis for his means-end or product oriented rationale for curriculum design (Arjun, 1998:24 as quoted by Malan, 2000:23):

- What educational objectives should the school aim to achieve?
- How does one select learning experiences that are likely to be useful in attaining these objectives?
- How should learners' experiences be organised for effective instruction?
- How will the effectiveness of the learning experience be evaluated?

Tyler's (1950) *Basic Principles of Curriculum and Instruction* (as quoted by Brady, 1996:6) emphasizes the importance of beginning the process of curriculum design with precise objectives.

Once these objectives have been delineated, it was argued, the selection of content, method and assessment strategies would follow. His (Tyler's) rationale has been used extensively by curriculum practitioners and forms the basis of Wheeler's well-known model of curriculum design that served as the main curriculum design model for several decades (Arjun, 1998:24, as quoted by Malan, 2000:23). The basic OBE philosophy for curriculum design is firmly rooted in both Tyler and Wheeler's models (Malan, 2000:23).

The taxonomies of educational objectives developed in the 1950s by Bloom (1956) and Krathwohl (1956) provide a framework within which to write objectives, and this helped to establish this tradition (Brady, 1996: 7).

After Bloom, came Mager, whose work was first published in 1962. "It ….. captured the imagination of many teachers and helped spark off a wave of enthusiasm (and controversy) over objectives" (McAvoy, 1985:29, as quoted by Malan, 2000:23). Guidelines (HTTP, 1999) on how to write learning outcomes in OBE closely resemble Mager's (1984:23-104) guidelines in terms of expected performance, the conditions under which it is attained, and the standards for assessing quality (Malan, 2000:23).

Benjamin Bloom, an American cognitive psychologist, initiated the mastery learning movement. Bloom's work was built on the premise that all learners are able to master desired outcomes if educators refashion the time and instructional parameters in which learning takes place. The emphasis of mastery learning is on input rather than on the culminating point of a set of learning experiences (Soudien & Baxen, 1997:451). This notion is reflected in OBE. The following main characteristics of mastery learning also reflected in OBE, apply:

- Ascertaining prerequisite knowledge or skills attaining goals (outcomes)
- A flexible timeframe to attain goals (outcomes)
- Using different media and materials to create enriched teaching/learning contexts
- Formative evaluation to provide feedback for both teaching and learning improvement

Mastery learning was initially introduced to provide intervention programmes for learners with mild abilities and those who were at risk in traditional educational settings (Guskey et al, 1995, as quoted by Malan, 2000:23). The authors state that research has confirmed the applicability and value of mastery learning in education to provide learners at all levels with similar, individualised assistance (Malan, 2000:23-24).

The competency based education movement, which was introduced in America towards the end of the 1960s (Malan, 2000:23) was a reaction to the changing job market in the United States (Soudien & Baxen, 1997:451; Waghid, 2001:127 and Malan, 2000:23), when questions arose about the role of education and whether it was preparing young people adequately for their future life roles (Soudien & Baxen, 1997:451). The same concern has been expressed about education in South Africa (Malan, 2000:23).

Quoting Towers in Schwartz and Covener (1994:326), Waghid (2001:127) finds competency based education referring to instructional and assessment procedures aimed at determining learner performance, and mastery learning signifying an approach to individualised instruction whereby learners are afforded time necessary to master units of curricula before proceeding to the next learning unit.

The basic premise of competency based educational practice is the integration of outcome goals, instructional experiences, and assessment devices. In practice, however, this approach remains largely rhetorical, partly because little agreement has been reached over what competency actually represents (Soudien & Baxen, 1997:451).

Six critical components on which competency based education is founded (Van der Horst & McDonald, 1997:10-11) (as quoted by Malan, 2000:23) are:

- Explicit learning outcomes with respect to the required skills and concomitant proficiency (standards for assessment)
- A flexible timeframe to master these skills
- A variety of instructional activities to facilitate learning
- Criterion referenced testing of the required outcomes
- Certification based on demonstrated outcomes
- Adaptable programmes to ensure optimum learner guidance

All six components are prominent in the OBE approach. Competency based education also supports the notion that the learner is accountable for his or her own achievements. This is another major tenet underpinning OBE (Malan, 2000:23).

Both competency based education and mastery learning accentuate predictable and measurable learner performance (Waghid, 2001:127). Outcomes-Based Education has appropriated themes from both movements in an attempt to shift the then educational practices to include objectives tied to "learner outcomes, core and extended curriculum development, mastery learning, accountability via an information management system, and criterion referenced assessment.” This represents a major paradigm shift from a content driven to an outcomes driven curriculum (Soudien & Baxen, 1997:451). Outcomes-Based Education is a model through which education can be changed incisively (Pretorius, 1998:ix).

In 1963, Glaser described criterion referenced measurement as that which locates a student’s test behaviour on a continuum ranging from “no proficiency”. Criterion referenced instruction and assessment is based on attaining specific outcomes and on testing for competence in terms of stated criterion. This form of instruction compares a learning outcome or mastery of competencies with a predetermined external standard. Success is measured by demonstration of standards, followed by remedial intervention as required. Criterion referenced assessment is the preferred mode of assessment in OBE (Butler, 2003:6 and Malan, 2000:24).

Butler (2003:6) realised that Spady’s OBE approach closely resembles Mager’s (1962) guidelines in terms of expected performance, conditions under which it is attained, and standards for assessed quality. OBE learning programme assessment and learners’ competence can be compared to specific criteria. Competency in the required outcome (learner behaviours) is demonstrated by the culmination of significant learning within a context, and a specific timeframe required by the individual learner (Butler, 2003:6).

Based on the above deliberation it is evident that OBE is firmly rooted in past educational approaches, and Malan (2000:28) has revealed that OBE does not represent a paradigm shift as advocated by OBE proponents. At best OBE may be described as an eclectic educational philosophy, taking the best from previous approaches and framing them in a new visionary system that meets the human resources appropriate to the needs and demands of democratic South Africa (Malan, 2000:28).

Not defying Malan’s findings that South Africa’s OBE is not a major educational paradigm shift, one has to point out that the most immediate origins of OBE in South Africa can be found in the competency debates in Australia and New Zealand that were closely followed in South Africa. These debates had a great influence on training and development discussions in the Congress of South African Trade Unions (COSATU), and many of the views eventually appeared in documents of the National Training Board (such as The National Training Strategy Initiative) and, subsequently, crystallised in the National Qualifications Framework (NQF). It was largely the result of deliberations within the NQF to integrate education and training that the debate on competencies was extended to education. ‘Competencies’ was reframed as ’outcomes’ in the department of Education (Jansen, 1998:322).

The historical account emphasises that Outcomes-Based Education did not emerge as a coherent and comprehensive curriculum reform in South Africa. Its origin lies in a number of desperate influences, both internal and external, both historical and contemporary, both educational and economic (Morabe, 2004:78). Therefore, making the paradigm shift towards Outcomes-Based Education and Training meant that new terminology and rules for learning had to be developed. The details of new rules have been clarified and the roles of players and spectators ironed out. In order to join the new game, one must make a paradigm shift from traditional learning towards Outcomes-Based learning. “Shifting the paradigm” (Olivier, 2001:29) really means an alternative answer or way of explaining solutions to problems by using the same concepts, approaches, constructs and methods in a slightly changed manner. A real paradigm shift involves a new approach to a problem or set of circumstances, based on a totally new point of departure and coupled with new thinking constructs (Morabe, 2004:79).

4.3.1 Outcomes-Based Education defined

Outcomes-Based Education (OBE), like most concepts in education, has been interpreted in many different ways. The term is often used quite inappropriately as a label for a great variety of educational practices that pay little more than lip service to the fundamental principle of OBE. OBE can be viewed in three different ways, namely as a theory of education, or as a systematic structure for education, or as classroom practice. Ultimately, one needs to align the systematic structure and the classroom practice with theory if one wants to have genuine Outcomes-Based Education. We can think of OBE as a theory (or philosophy) of education in the sense that it embodies and expresses a certain set of beliefs and assumptions about learning, teaching and the systematic structures within which these activities take place (Killen, 2000:2).

Outcomes do indeed indicate clear learning results that learners have to demonstrate at the end of significant learning experiences. Outcomes have to show *what learners can actually do with what they know and learned*. They are actions/performances that embody and reflect learner competence in using content, information, ideas and tools successfully. Geyser (1999) is quoted by Butler (2004:3) as saying that when learners do important things with what they know, they have taken a significant step beyond knowing in itself. Vella, Berardinelli and Burrow (1998, as quoted by Butler, 2004:3) reminds us of the importance of accountability mechanisms (learner assessment) that directly reflect student performance and help learners “know what they know”. Thus outcomes describe the results of learning over a period of time, the results of what is learned versus what is taught (Butler, 2004:3).

In Spady's words (Killen, 2000:2) Outcomes-Based Education means clearly focusing and organising everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organising the curriculum, instruction, and assessment to make sure this ultimately happens. Such an approach presupposes that someone can determine what things are "essential for all students to be able to do", and that it is possible to achieve these things through an appropriate organisation of the education system and through appropriate classroom practice (Killen, 2000:2). Butler (2004:3) quoted Spady (1994) defining OBE as a "…. Comprehensive approach to organising and operating an education system that is focused in and defined by the successful demonstrations of learning sought from each student".

An Education Department of Western Australia document describes OBE as "an educational process which is based on trying to achieve certain specified outcomes in terms of individual student learning. Thus, having decided what are the key things students should understand and be able to do or the qualities they should develop, both structures and curriculum are designed to achieve those capabilities or qualities. Educational structures and curriculum are regarded as means not ends. If educational structures and curricula do not do the job, they are rethought (Willis & Kissane, 1995 and Butler, 2004:4)".

Put differently, Willis and Kissane (1997), and Tucker (2004:2) define Outcomes-Based Education as a process that involves the restructuring of curriculum, assessment and reporting practices in education to reflect the achievement of higher order learning and mastery rather than the accumulation of course credits. Lorenzen (1999:1) and Acharya (2003:7) find OBE to be a method of teaching that focuses on what students can actually do after they have been taught. All curriculum and teaching decisions are made based on how best to facilitate the desired outcome. This leads to planning processes in reverse of traditional educational planning. The desired outcome is selected first and the curriculum is created to support the intended outcome.

Behind these definitions lies an approach to planning, delivering and evaluating instruction that requires administrators, teachers and learners to focus their respective attention and efforts on the desired results of education, results that are expressed in terms of individual student learning (Killen, 2000:2; Butler 2004, 4 and Malan, 2000:28). The shift towards OBE is similar to the total quality movement. The best way for individual organisations to get where they want to go is first to determine where they want to be and then to plan backwards to determine the best way to get from here to there. Proponents of Outcomes-Based Education assume there are many ways to arrive at the same result (Butler, 2004:4).

4.3.2 Implications of OBE

According to Spady and Marshall (1994:1, as quoted by Pretorius, 1998:ix), Outcomes-Based Education is nothing new. It has always been with us. We are Outcomes-Based when we teach a child to cross a road safely. We know exactly what the child must do and see it in our mind's eye. We indeed go to great lengths to teach the skill correctly to the child and insist that he practices it until we are convinced that he can do it safely. This is the true Outcomes-Based Education.

Pretorius (1998: ix) came up with similar interpretation by quoting Kudlas (1994:32), who states that OBE is an age-old, common sense approach to education. It is a process that focuses on what is to be learned – the outcome, which is a demonstration of learning. It is what the student has to know or do.

Spady (1994:18, as quoted by Pretorius, 1998: ix) defines outcomes as "high-quality, culminating demonstrations of significant learning in context." In another unpublished work, Spady describes an outcome as a demonstration of learning that occurs at the end of a learning experience. It is a result of learning and an actual visible, observable demonstration of three things: knowledge combined with competence, combined with orientations – the attitudinal, effective, motivational and relational elements that also make up a performance. Further, this demonstration happens in a real life setting, and is therefore influenced and defined by elements and factors that make up that setting, situation or context (Pretorius, 1998: ix).

To reiterate but not differing from Pretorius' extraction from Spady (1994:1), Killen (2000:2) quoted Spady (1994:1) to indicate that the main idea behind Spady's definition is that OBE is an approach to planning, delivering and evaluating instruction that requires administrators, teachers and students to focus their attention and efforts on the desired results of education, results that are expressed in terms of individual student learning (Acharya, 2003:7 and Killen, 2000:2).

Consequently, an outcome is not a great deal of content or knowledge that the learner has memorised. It is also not a test score, symbol or percentage. It is a visible, observable demonstration, that is, something that the learner can do as a result of the entire range of learning experiences and capabilities that underlie it (Pretorius, 1998: ix).

When education is Outcomes-Based, it means that a community decides beforehand about the following three questions:

1. What should our learners know after the completion of their education?

2. What must they be able to do?
3. What do they need to feel or believe? (Acharya, 2003:7 and Fitzpatrick, 1991: 18 as quoted by Pretorius, x)

Once it has been determined what learners need to achieve, the outcomes are deduced from these decisions. Outcomes are broken down so that learners, teachers and parents know what they need to do to be able to succeed at every level, and learners are assessed periodically to measure their progress. Before they leave school learners must demonstrate that they have mastered the outcomes. Consequently, to base education on outcomes means to begin planning with the end in mind: one should first determine the learning result and "define, develop, derive, and organise all of our curriculum designing and instructional planning, teaching, assessing, and advancement of students on that desired demonstration" (Pretorius, 1998: x).

Thus, the OBE's instructional planning process is a reverse of that associated with traditional educational planning. The desired outcome is selected first and then the curriculum. Instructional materials and assessments are created to support the intended outcome (Spady 1988; 1993, as quoted by Acharya, 2003:7). All curriculum and teaching decisions are based on how best to facilitate the desired final outcome (Acharya, 2003:7).

To shed more light on what the authentic model of OBE signifies, it is useful to mention Spady and Marshall's (1991, as quoted by Brady, 1997:9 and Pretorius, 1998: x) identification of three Outcomes-Based approaches that indicate an evolutionary sequence:

- *Traditional Outcomes-Based Education* is the design that emerges from the existing curriculum. Outcomes are defined as instructional objectives based on the existing curriculum. They focus on the mastery of content, with the emphasis on remembering and understanding. The major dangers of this approach are that the culminating demonstration is often limited to small segments of instruction that makes each an end in itself. The content of the curriculum remains the same and the concept of the total person is rarely the driving force.
- *Transitional Outcomes-Based Education* is an approach that moves away from existing curricula to identify outcomes that reflect higher order competencies that cut across traditional subjects and use content to cultivate higher order competencies such as problem solving, critical thinking, effective communication and technological applications.
- *Transformational Outcomes-Based Education* is the highest evolution of the Outcomes-Based concept. It moves away not only from the existing curriculum, but also from the given structures of schooling. No existing features of the school's instruction are considered

untouchable. All curriculum design, strategic planning and resource allocation reflect the scope and nature of the outcomes. The curriculum is designed from future-driven exit outcomes.

After considering the broad transformational intent of the South African curriculum, Claassen (1998:35) identifies one transformational approach that is particularly aimed at the democratization of the curriculum, namely the so-called "socio-constructivist" approach. According to this approach, the curriculum is the result of negotiation. The amount of learning is reduced and the focus is on forming conceptual frameworks into which new information is integrated. Holistic frameworks, rather than atomistic details, are conveyed by the curriculum. Boundaries between disciplines are blurred. The content is not structured around disciplines, but rather around themes and real-life problems. It is apparent that OBE, at least as it is espoused in official South African policy, adheres closely to a socio-constructivist approach. The transformation perspective is also evident in the assessment procedure (Claassen, 1998:35).

This kind of OBE offers a dialogue between the learner and the curriculum where the learner interacts with sources of knowledge, reconstructs knowledge, and takes responsibility for his or her own learning outcomes. In the same way the teacher becomes a facilitator in the teaching and learning situation instead of acting as a source of information and transferring content to learners (Malan 2000:26 and Claassen, 1998:34). Malan (2000:26) points out that the mastery learning and competency based education movements influence the transformational character of OBE.

4.3.3 Principles of Outcomes-Based Education

The main idea behind Spady's definition is that OBE is an approach to planning, delivering and evaluating instruction that requires administrators, teachers and students to focus their attention and efforts on the desired results of education, results that are expressed in terms of individual student learning. Within this broad philosophy, there are two common approaches to OBE. One approach emphasises student mastery of traditional subject-related academic outcomes (usually with a strong focus on subject-specific content) and some cross-discipline outcomes (such as the ability to solve problems or to work co-operatively). These two approaches correspond to what Spady (1994) calls traditional/transitional OBE and transformational OBE (Killen, 2000:2).

Quoting Spady (1994), Killen (2000:2) indicates that learning is not significant unless the outcomes reflect the complexities of real life and give prominence to the life-roles that learners will face after they have finished their formal education. This emanates from transformational approach to OBE in which outcomes are "high-quality, culminating demonstrations of significant learning in context". This notion of orienting education to the future needs of students, and of society in general is the underlying principle of key competencies (Killen, 2000:2). In a less formal way, it is behind statements such as “The learning outcomes comprise the knowledge, understanding, skills and attitudes that students should acquire to enable them to reach their full potential and lead successful and fulfilling lives as individual, as of the community and at work” (Northern Territory Board of Studies, 1998:2, as quoted by Killen, 2000:2).

According to Spady (1994) (as quoted by Tucker, 2004:3), Outcomes-Based Education shapes the way of designing, developing, delivering, and documenting the teaching and learning experience in terms of the achievement of predetermined outcomes (Tucker, 2004:3). Teaching in an Outcomes-Based system requires the development of a clear focus on what is essential for learners to be able to do successfully, and then finding and deciding strategies for learners to achieve this (Spady, 2001) (as quoted by Tucker, 2004:3). A fundamental principle of OBE is the expectation about the role of learners in the education process were, according to McDaniel et al. (2000) (as quoted by Tucker, 2004:3) learners are challenged to be:

1. more active as learners rather than being passive recipients of knowledge,
2. independent as learners; and
3. intrinsically motivated.

While learners are engaged in these learning activities, the outcome should reflect the complexities of real life and give prominence to the life-roles that learners will face after they have finished their formal education (Spady, 1994:18, as quoted by Killen, 2000:2).

In addition to the idea that outcomes should describe long-term significant learning, three basic premises underpin OBE:

1. All learners can learn and succeed, but not in the same time or in the same way.
2. Successful learning promotes even more successful learning.
3. Schools (and teachers) control the conditions that determine whether or not students are successful at school learning (Killen 2000:3-4; Butler, 2004:7;

According to Butler (2004:8) and Killen (2000:4) Spady (1994) developed four essential principles of OBE that strengthen the conditions for both learner and teacher success:

- ❖ Clarity of focus
- ❖ Design down

- ❖ High expectations
- ❖ Expanded opportunities

Clarity of focus. This principle infers that curriculum development, implementation and evaluation should be geared by the outcomes that are expected as the culminating demonstrations of the learners. According to Willis and Kissane, (1997, as quoted by Butler, 2004:8), the principle clearly delineates that the articulation of the desired end point is essential for successful outcomes. Curriculum planners and educators have to identify a clear focus of what they want learners to be able to demonstrate at the end of significant learning time. Once these outcomes have been identified, the curriculum is constructed by the backward mapping of knowledge and skills (Butler, 2004:8).

Design down. This principle is often referred to as designing back and it is inextricably linked to the first principle. According to Killen (2000:4) this principle means that the starting point for all school curriculum design must be a clear definition of the significant learning that students have to achieve by the end of their formal education. Once this has been done, all instructional decisions are then made by tracing back from this “design end result” and identifying the “building blocks” that will be required to achieve that end. This (explains Killen, 2004:4) does not mean that curriculum design should be a simple linear process, but it does mean that there should be direct and explicit links between all planning, teaching and assessment decisions and the significant outcomes that students ultimately have to achieve.

High expectations. According to this principle, teachers should have high expectations for all students. Killen (2000:5) indicates that there is ample evidence in the literature that teachers must establish high, challenging standards of performance in order to encourage learners to engage deeply with the issues about which they are learning. Helping learners to achieve high standards is linked very closely with the idea that: “successful learning promotes more successful learning” (Spady, 1994 as quoted by Killen, 2000:5). He further elaborates that when learners experience success, it reinforces their learning, builds their confidence and encourages them to accept further learning challenges.

Expanded opportunities. Intellectual quality is not something reserved for a few learners: it is something that should be expected of all learners. Killen (2000:5) finds this to be the link to the fourth basic principle. He further elaborates that teachers must strive to provide expanded opportunities for all learners. This principle, Killen (2000:5) reiterates, is based on the idea that not all learners can learn the same thing in the same way and in the same time. Most learners can achieve high standards if they are given appropriate opportunities – what really matters is that learners learn the things that are important: not that they learn them in a particular way or by some arbitrary point in time. The exploration and practical application of each of these principles, as suggested by Spady (1994) and Killen (2000) (as quoted by Butler, 2004) is as follows:

Table 4.1 Outcomes-Based Principles – explanation and application (Source: Spady, 1994; Killen, 2000)

OBE Principle	Explanation	Application to practice
Clarity of focus	Focus on what you want learners to be able to do successfully	- Help learners develop competencies - Enable predetermined significant outcomes - Clarify short and long term learning intentions - Focus assessments on significant outcomes
Design down	Begin curriculum design with clear definition of the significant learning that learners should achieve by the end of their formal education	- Develop systematic education curricula - Trace back from desired end results - Identify "learning building blocks". - Link planning, teaching and assessment decisions to significant learner outcomes
High expectations	Establish high, challenging performance standards	- Engage deeply with issues learners are learning - Push beyond where learners would normally have gone
Expanded opportunities	Learners do not learn the same thing in the same way in the same time	- Provide multiple learning opportunities matching learners' needs with teaching techniques

It is only when the above principles are used as the core of an educational system that we can legitimately call that system Outcomes-Based Education. We cannot, for example, conveniently ignore the principle of designing back and still claim to have an OBE system (Killen, 2000:5).

4.4 OBE in South Africa and implementation

Paragraph 4.2 briefly explained how OBE originated in South Africa and paragraph 4.2.1 touched on the curriculum model that South Africans stand for. It should be noted that South Africa does not distance itself from the OBE as espoused by different authors, especially William Spady and Roy Killen. In fact, they are the ones who played an important role in the designing of the kind of OBE that South Africans stand for. The implementation of Curriculum 2005 and the OBE model presents a unique opportunity for systematic change and improvement of quality in South African education. It is doubtful if any country has attempted as radical a change in so diverse a situation. South Africa is, in the best sense of the word, a world in one country (Botha, 2002:13).

Unlike other countries were OBE has been implemented, the Constitution of the Republic of South Africa forms the basis for social transformation in our post-Apartheid society. The imperative to transform South African society by making use of various transformative tools, stems from a need to address the legacy of Apartheid (as mentioned in most paragraphs of this text) in all areas of human activity, and in education in particular. Social transformation in education is aimed at ensuring that the educational imbalances of the past are redressed, and that equal educational opportunities are provided for all sections of our population. If social transformation is to be achieved, all South Africans have to be educationally affirmed through the recognition of their potential and the removal of artificial barriers to the attainment of qualification (DoE, 2003b: b). In its emphasis on results and success, on outcomes and their possibility of achievement by all at different paces and times rather than on a subject-bound, content-laden curriculum, this constitutes a decisive break with all that was limiting and stultifying and in the content and pedagogy of education (Chisholm, 2003:3). OBE and C2005 provide a broad framework for the development of an alternative to Apartheid education that is open, non-prescriptive and reliant on teachers creating their own learning programmes and learning support material (DoE, 1997a, b, and d., as quoted by Chisholm, 2003:3).

Outcomes-Based Education, being the foundation for the curriculum in South Africa, strives to enable all learners to reach their maximum learning potential by setting the Learning Outcomes to be achieved by the end of the education process (DoE, 2003b: 2).

The following can be said about Outcomes-Based Education in South African context. It is:

- Aimed at the achievement of high levels of knowledge, skills and values through the setting of high standards
- Based on realising the full potential of each learner as a citizen of a democratic South Africa
- Reliant on caring and competent teachers dedicated to teaching
- A learner-centred, activity based approach to learning and teaching
- Oriented to South African conditions
- An approach that is common across the world
- A unique blend of knowledge, skills and values drawn from South Africa, Africa and the world.

Outcomes-Based Education considers the process of learning as important as the content. Both the process and the content of education are emphasised by spelling out the outcomes to be achieved at the end of the process (DoE, 2004c)

This vision is captured by the learning goals formulated by the South African Qualifications Authority (SAQA) in its seven critical outcomes statements (COs) (Table 4.1), which should underpin all curricula (Taylor, 1999:110).

TABLE 4.2 The Critical Outcomes statements
(DoE, 2003a:2)

1. Identify and solve problems in which responses display that responsible decisions have been made using critical and creative thinking.
2. Work effectively with others as a member of a team, group, organisation, community.
3. Organise and manage oneself and one's activities responsibly and effectively.
4. Collect, analyse, organise, and critically evaluate information.
5. Communicate effectively using visual, mathematical, and/or language skills in the modes of oral and/or written persuasion.
6. Use science and technology effectively and critically, solving, showing responsibility towards the environment and health of others.
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

What the outcomes achieve, in conjunction with SAQA's additional five critical outcomes statements (Table 4.2), is not only to target higher order learning goals, but to tie the skill components of these goals to the need to understand the knowledge principles underlying these skills. They also relate knowledge and skills to the social, political and economic contexts in which they are acquired and applied (Taylor, 2004:111). The critical outcomes are reframed and strengthened by Dr. William Spady and Prof. Roy Killen of Australia (Spady, 2004:168). Sceptical as he (Spady) was, the twelve COs has formed the bedrock of the country's Curriculum 2005 OBE thinking, reform, and policy making for several years, and they presently serve as the standard against which all Higher Education and Further Education and Training (FET) programmes in South Africa are measured (Spady, 2004:169).

Table 4.3 SAQA Additional five Outcomes
(DoE, 2003a:2)

8. Reflecting on and exploring a variety of strategies to learn more effectively.
9. Participating as responsible citizens in a life of local, national, and global communities.
10. Being culturally and aesthetically sensitive across a range of social contexts.
11. Exploring education and career opportunities.
12. Developing entrepreneurial opportunities.

During the reframing and strengthening process, Spady and Killen felt that it is essential to start by determining the deeper essence and most empowering intention of each of the original twelve CO statements – as if their authors want something significant and powerful to result from each. It was clear to them that the SAQA Outcomes reflect qualities and competences that are very germane to high quality living and are not limited to, or bound by specific subject content. They found that the critical outcomes provide a rich starting point from which sound learning experiences could be designed – experiences that would encourage in-depth learning over a continuous period of years. In addition, it did not appear to them that most of the statements could validly be "measured" by conventional paper-pencil examination. Authentic performance of some kind or other is required (Spady, 2004:169).

Fourteen essential elements of each of the SAQA Critical Outcomes were identified and were categorised according to their basic nature: COs are inherently

- life-role performances; or
- broad enabling competences; or
- orientations or ways of thinking.

If effective Life Role is what ultimately makes an outcome "significant" because "it really matters in the long run", then the latter classification framework suggests that the SAQA COs contain five of them (Spady, 2004:170). These five COs (Spady, 2004:170) could be treated as the "ultimate proof" of the educational performance pudding: that learners function effectively as life managers, community and environmental stewards, as citizens, in their careers, and as opportunity creators, all abilities that are linked directly to the world in which they operate. The other nine statements are viewed as "Enabling" or "Supporting" Outcomes because they provide some of the key skills and orientations that make effective Life Role Performance possible. A general framework that shows the connections among the three kinds of Outcomes was then designed.

Ultimately the COs were translated into role performance language. Spady deliberately chose not to replicate words used in the essence statements in order to make each statement distinctive. He selected words that reflect both the substance and spirit of the original CO statements, and the essence statement derived from it (Spady, 2004:170). Fully elaborated Role Performance Statements were developed for each of the five life role outcomes in order to put the new SAQA outcomes framework into operation.

The formation of OBE philosophy has mainly been the work of William Spady. According to Cretchley and Castle (2001, as quoted by Constandius, 2006:2), OBE was influenced by the behaviourist tradition in psychology, which focuses on external, observable behaviour. In South Africa, OBE is not limited to behaviourist concepts, but includes knowledge, skills, and attitudes that underlie performance. The quality of learning is measured by the outcome (success of learning) versus the input of the facilitator. The OBE system has also been introduced in countries like the United States, Canada and New Zealand. The South African version of OBE (the underlying philosophy behind South Africa's Curriculum 2005), points to a variety of practices like contextualised learning, student-centred, collaborative and interactive learning, critical thinking skills and problem-solving, self-empowerment, integrated skills, reflexive competence and the processes of learning (Constandius, 2006:2).

Ultimately, the implementation began in 1998 in grade 1, followed by grade 2 in 1999, grades 3 and 7 in 2000, grades 4 and 8 in 2001, and was supposed to be followed by grade 5 and 9 in 2002. As the critics had warned, the implementation became extremely problematic, resulting in the establishment of the Chisholm Committee by the then newly appointed Minister of Education. After a three-month study in 2000, the committee concluded that the complexity of the structure and design of the curriculum had compromised the implementation of C2005. Furthermore, poor departmental support for teachers, weak support of teacher training, tight timelines, the lack of enough learning support materials, and the general lack of resources had negatively affected the implementation of C2005 (Chisholm, 2001:27 and Howie, 2001:44-45).

A Ministerial Review Committee was established by the Minister of Education in response to the findings of the Chisholm Committee and given the task of refining the C2005 policy documents. A Ministerial Project Committee was established to lead, plan, and implement the process. A task team of eight coordinators of the learning area working groups and four additional coordinators were appointed (Howie, 2003:45).

The Report of the Ministerial Committee established to review the curriculum gave a wide-ranging critique of the curriculum. It argued that while there was overwhelming support for the principle of OBE and C2005, which had generated a new focus on teaching and learning, implementation has been confounded by the following factors (Chisholm, 2003:3; DoE, 2001:21-22 and Cowie, 2001:45):

- There was wide support for the curriculum changes envisaged (especially its underlying principles), but levels of understanding of the policy and its implications were highly varied.
- There were basic flaws in the structure and design of policy. In particular, the language was often complex and confusing (including the use of unnecessary jargon). Notions of sequence, concept development, and the scope of the outcomes and learning areas resulted in crowding of the overall curriculum.
- There was a lack of alignment between curriculum and assessment policies, with insufficient clarity in both areas.

- Training programmes were often inadequate in terms of the concept, duration and quality, especially early in the implementation process.
- Learning support materials varied in quality, and materials were often unavailable.
- Follow-up support for teachers and schools was far too little.
- Timeframes for implementation were unmanageable and unrealistic, the policy was released before the system was ready, with rushed timeframes.

In order to address these issues the Review Committee proposed the introduction of a revised curriculum structure with changes in teacher orientation and training, learning support materials and organisation, resources and staffing of curriculum structures and functions in national and provincial education departments (Chisholm, 2003:4).

At the core of the Revised National Curriculum Statement are eight learning areas stated in The General Education and Training (GET) band (DoE, 2001b:13) (as quoted by Howie, 2001:45) that affirm that each pupil will:

- Be equipped with linguistic skills and the aesthetic and cultural awareness to function effectively and sensitively in a multilingual and multicultural society.
- Display a spirit of curiosity to enable creative and scientific discovery and display an awareness of health promotion.
- Adapt to an ever-changing environment, recognising that human understanding is consistently challenged and hence changes and grows.
- Use effectively a variety of problem-solving techniques that reflect different ways of thinking, recognising that problem-solving contexts do not exist in isolation.
- Use effectively a variety of ways to gather, analyse, organise, and evaluate numerical and non-numerical information and then communicate it effectively to a variety of audiences and models.
- Make informed decisions and accept accountability as a responsible citizen in an increasingly complex and technological society.
- Display the skills necessary to work effectively with others and organise and manage oneself, one's activities, and one's leisure time responsibly and effectively.
- Understand and show respect for the basic principles of human rights, recognising the interdependence of members of society.
- Be equipped to deal with spiritual, physical, emotional, material, and intellectual demands in society.
- Have an understanding of and be equipped to deal with the social, political, and economic demands on a South African as a member of a democratic society in the local and global context.

The national curriculum statement also includes the critical and development outcomes derived from the Constitution. These describe the kind of citizen that the education and training system should produce (Howie, 2001:46). The critical outcomes are as outlined in table 4.1.

The GET band is divided into the foundation phase (grades R-3), the intermediate phase (grades 4-6), and the senior phase (grades 7-9). November 2001, the process of developing eight learning area statements (i.e., learning outcomes and assessment standards) and the qualifications document was completed. The main differences between the original C2005 documents and the revised versions are that there are fewer curriculum design features, fewer outcomes, environmental education was integrated into the curriculum, as were human rights and inclusivity issues, there are assessment exemplars, there is clear guidance to teachers on what to teach in every grade and phase, there are implementation guidelines, and there is a qualification document for GETC. The revised National Curriculum Statement became policy at the end of 2001 (Howie, 2001:47).

After the GET band, Further Education and Training (FET) is the largest and most complex phase of learning. Despite its importance and size, it has never been conceived of as a coherent system. There are thirteen types of providers that can be categorised into four main sectors: secondary schools, which contain the majority of all learners; publicly funded colleges; private education and training providers; and enterprise-based education and training (RSA, 1997(b):ix) (as quoted by Mothata, 1998, 22).

Further Education and Training (FET) curricula are of special interest to the higher education institutions that want to provide a strong foundation for their courses. As such, it has to build on and be sequential to the GET certificate (GETC) and developments in Curriculum 2005. The National Strategy for FET, 1999-2001 (DoE, 1999) (as quoted by Howie, 2001:48) includes the following strategic objectives in learning and teaching:

- Management of learning programs and qualifications framework(s) and innovation
- Increased learner participation and achievement, particularly in mathematics, physical science, technology and engineering.
- Learning support service.
- Flexible learning.
- Ongoing professional development.
- Articulation and learner mobility.
- Technical college and senior certificate examinations.

The curriculum framework for FET is being developed as a single national framework for schools, colleges, and private providers. It is also Outcomes-Based and learner centered, with unit standards and registered programs drawn from twelve fields of learning (Howie, 2001:48). Field of learning or learning field is explained by DoE (2003a:9) as a category that serves as a home for cognate subjects, and that facilitates the formulation of rules of combination for the FETC (general) (see chapter 7). FET focuses on preparing pupils for higher education, for work, and for education for personal and social development (Howie, 2001:47).

4.5 National Curriculum Statement

In 1999, a process of reviewing and modernising Grade 10 – 12 school programmes was initiated. The aim of the review and modernisation process was, amongst others, to re-conceptualise and rewrite the interim syllabi for Grade 10 -12 into new, integrated and responsive Learning Programmes that would broaden access to a range of career options for young and adult learners. This decision was not fully implemented, but rather served as a prelude to the development of the National Curriculum Statement Grade 10-12 (General) (DoE, 2003a:5).
The process included, amongst others, to:

- Establish new standards (expressed as Learning Outcomes) for grade 10-12 (General);
- (re)Design Grade 10-12 Learning Programmes aimed at achieving the Learning Outcomes;
- Establish programmes aimed at equipping educators, managers and officials with the skills and knowledge required to implement Learning Programmes effectively and efficiently; and
- Lay the foundation for the introduction of Curriculum 2005 in Grade 10 – 12.

The National Curriculum Statement Grades 10-12 in general lays a foundation for the achievement of these goals by stipulating Learning Outcomes and Assessment Standards, and by spelling out the key principles and values that underpin the curriculum. It also strives to give expression to the values of democracy, human rights, social justice, equity, non-sexism, non-racism and ubuntu (human dignity), in line with the Constitution of the country. In order to attain that, the NCS is based on the following principles:

- Social transformation
- Outcomes-Based Education
- High knowledge and high skills
- Integration and applied competence
- Progression
- Articulation and portability
- Human rights, inclusivity, environmental and social justice

- Valuing indigenous knowledge systems and
- Credibility, quality and efficiency.

These principles serve as basis for a new curriculum development. Their implication for curriculum development can be summed up as follows:

4.5.1 Social transformation

The imperative to transform South African society by making use of various transformative tools stems from a need to address the legacy of Apartheid in all areas of human activity and in education in particular. The Department of Education realised that social transformation in education is aimed at ensuring that the education imbalances of the past are redressed, and that equal educational opportunities are provided for all sections of our population. In order to achieve this, all South Africans have to be educationally affirmed through the recognition of their potential and the removal of artificial barriers to the attainment of qualification (DoE, 2003b:2).

4.5.2 Outcomes-Based Education

It forms the foundation for the curriculum in South Africa: Curriculum 2005 with the RNCS for GET and NCS for FET. It strives to enable all learners to reach their maximum learning potential by setting the Learning Outcomes to be achieved by the end of the education process. OBE encourages a learner centred and activity based approach to education. Therefore, curriculum developers must vary their assessment methods and techniques to be learner paced and learner based (DoE, 2003b:2).

The National Curriculum Statement builds its Learning Outcomes for Grades 10-12 on the Critical Outcomes (Table 4.1), envisaged citizen, and Developmental Outcomes (Table 4.2)(referred to as SAQA additional outcomes) that are inspired by the Constitution and developed through a democratic process (DoE, 2003b:2). It should be noted that the developmental outcomes, unlike critical outcomes in education, serve to provide the evidence that outcomes are achieved. All the Outcomes will be dealt with in paragraph 5.5.

4.5.3 High knowledge and high skills

The National Curriculum Statement specifies the minimum standards of knowledge and skills to be achieved at each grade and sets high, achievable standards in all subjects (DoE, 2003b:2).

4.5.4 Integration and applied competence

To achieve applied competency as defined in the National Qualification Framework NQF), integration of knowledge and skills across subjects and terrains of practice is crucial (DoE, 2003b:3).

4.5.5 Progression

Progression refers to the process of developing more advanced and complex knowledge and skills (DoE, 2003b:3). The content and context of each grade should show progression from simple to complex and assessment standards, and should also show an increased level of expected performance per grade (DoE, 2003b:3).

4.5.6 Articulation and portability

The Department of Education (2003b:3) defines articulation as the relationship between qualifications in different NQF levels or bands in ways that promote access from one qualification to another. In order to achieve articulation between the FET certificate and GET and Higher Education (HE) bands, the development of each Subject Statement included a closed scrutiny of exit level expectations in the GET learning areas, and of the learning assumed to be in place at the entrance levels of the cognate disciplines in Higher Education (DoE, 2003b:3).

Portability ((DoE, 2003b:3) refers to the extent to which parts of a qualification (subjects or unit standards) are transferable to another qualification in a different learning pathway of the same NQF band. To enable portability, subjects contained in the NCS Grades 10-12 (General) compare with appropriate unit standards registered on the NQF.

4.5.7 Human rights, inclusivity, environmental and social justice

The National Curriculum Statement should be sensitive to issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors (Free State DoE, 2005:4)

4.5.8 Valuing indigenous knowledge systems

Indigenous knowledge systems in the South African context refer to a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years. Thus, the NCS has infused the indigenous knowledge systems into the Subject Statements and it also acknowledges the rich history and heritage of this country (South Africa) as import contributors to nurturing the values contained in the Constitution of the country. As many different perspectives as possible have been included to assist problem solving in all fields (DoE, 2003b:4).

4.5.9 Credibility, quality and efficiency

The NCS grades 10-12 (general) aim to achieve credibility through pursuing a transformational agenda and through providing an education that is comparable in quality, breadth and depth to those of other countries (DoE, 2003b:4).

4.6 Constructivism and Outcomes-Based Education

Constructivist theory underlies Outcomes-Based Education, which is the system prescribed for education in South Africa. OBE refers to important aspects of learning. Fenwick (2001) (as quoted by Constandius, 2006:1) puts the main focus of constructivist learning on reflection while Schön's (1987) (as quoted by Constandius, 2006:1) interest lies in what the actual triggers are for reflection. A trigger could be a surprise or an experience of discomfort. Schön refers to reflection that is closely bound up with action, and instead of applying theories and concepts to practical situations, he suggests that students should learn to frame and reframe the problems they are facing, test out different interpretations, then modify their actions as a result (Constandius, 2006:1).

This concept connects with the OBE in the sense that in OBE teaching and learning is learner centred, with emphasis on group work and developing the ability of people to think critically and research and analyse things for themselves ((Vermeulen, 1998:41-42). In South Africa, OBE is not limited to behaviourist concepts, but includes knowledge, skills, attitudes and values that underlie performance (Constandius, 2006:1 and Vermeulem, 1998:41).

In contextualised learning (residing in constructivism and eminent in OBE) it is important to relate the learning to previous experience, like life experience, fears or prejudices. Experience has an influence on generating meaning and we cannot divorce our learning from our lives. It is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on (Constandius, 2006:1). Student centred learning in science could be interpreted as an individual approach to learning. Students are given more scope to identify their own problems and choose suitable method to solve the problem. This leaves more space for creativity because the one idea influences and enhances the other (Constandius, 2006:2).

The next important aspect is interactive learning, where the student is actively involved in the learning process. Students and teachers should engage in lively dialogue, i.e. Socratic learning. The construction of ideas comes largely from discussion and debate. The topic and the flow of the class debate/discussion emerge from both teacher and learner. The teacher gives elements of a problem/structure to scaffold the co-construction of knowledge. The concept scaffolding (paragraph 3.4.4) is used by Bruner (1975) to describe the support given in order to construct and extend skills to higher levels of competency (Constandius, 2006:1).

The above discussion clearly shows that there is a close relationship between OBE and the constructivist approach to science teaching and learning. They are both child centred, promote critical thinking, and support teamwork. It should be clear that for learning to take, as Constandius (2006:6) puts it, one needs a combination of characteristics to function together simultaneously. The combinations and proportions of these parts therefore need to be carefully selected to fit the particular learning field. The OBE system (Constandius, 2006:1) includes many important aspects of learning, but pin-pointing the focus or stipulating the combinations of elements for science is a complex process. On his deliberation about the system of OBE in South Africa, Botha (2002) indicates that the new curriculum contains elements of almost any innovation that has ever been tried (education).

4.7 Conclusion

The foregoing is genuinely transformational. It reveals things about the most "significant"/life-relevant outcomes within the SAQA framework and as envisaged by the NCS, and it really opens the door to an entirely different universe of possibilities concerning learning, education, curriculum, instruction, assessment (see chapter 5), credentialing, and professional preparation. The paradox is that this new "paradigm" (Spady, 2004:176), is not grounded in abstract theory or some outrageous form of idealism, but in the very essence of the Critical Outcomes framework that is supposed to be guiding educational design and implementation at all levels of the South African system (Spady, 2004:176).

The successful and effective implementation of the OBE approach in FET is arguably South Africa's education battle at the moment. The challenges for South Africans in this regard are enormous. Despite this challenge, an educational system that focuses on a more holistic, context-appropriate set of outcomes is possibly the cure for what ails South Africa's education system and is possibly the right thing at the right time to improve the quality of the South African education and to transform the system. OBE can, if given the chance, lead to the empowerment of a still disenfranchised and marginalized South African society (Botha, 2002:15-16). There are many positive sides to OBE, as its transformational approach indicates. It brings about a national focus on education as a means to an end and not an end in itself (Malan, 2000:28).

Educational practitioners have to become more attuned to planning and managing learning environments and must be committed to the ideal of valid and reliable assessment. Thus, the next chapter (Chapter 5) discusses Outcomes-Based Assessment in science.

CHAPTER 5

Outcomes-Based Assessment and the standards of assessment

5.1 Introduction

The last decade has witnessed a growing recognition of the need for significant changes in educational assessment practices. The calls for reform are directed not only at a large scale, standardized tests, but also at classroom assessment practices (Kyriakides & Campbell, 1999:109). Even in South Africa, it is widely agreed in educational policy circles that a paradigm shift in assessment is required in order to ensure that the assessment practices guide, support and underpin the country's transformative Outcomes-Based model for education and training. However, the practical implications of this shift are not well understood by educators and education practitioners in the country (Pahad, 1999:247).

The call for reform has not fallen onto the deaf ears, as the interest among teachers of science has been noted by NCTM, 1995 (as quoted by Driscoll & Bryant; 1998:1). Most teachers are learning the professional crafts of assessment, in order to become knowledgeable and adept at "the process of gathering evidence about a student's knowledge of ability to use, and disposition toward science and making inferences from that evidence for a variety of purpose" (Driscoll & Bryant, 1998:1).

A major difficulty facing curricular and instructional reform is the mismatch between the curricular and instructional reform efforts and existing classroom assessment practice. In order to successfully change practice, the professional development programs must concurrently address the curricular, instructional, and the assessment issues associated with reform. These three dimensions form a knowledge base for understanding teaching, assessing, and learning, or pedagogical content assessment knowledge (Shepardson, 2001:11).

Assessment always has, and still represents an important cornerstone of education and is very critical in the South African National Curriculum Statement (NCS), especially for Grades 10 – 12 (DoE, 2003a:4). Certainly, as indicated in paragraph 2.4.5, educators possess a basic need of knowing whether their educational intentions have been realised, to what extend their educational activities achieve their goals, how these activities affect different students and how best to plan for continuous and optical instruction (Tamir, 1998:761). Simply put, assessment is a process of collecting and interpreting evidence in order to determine the learners' progress in learning and to make judgement about learners' performance (DoE, 2003b:55). The present national curriculum statement (NCS) is designed in such a way that it informs educators of what is expected of them, and also what is expected of the learners (DoE, 2003a:4-5).

Therefore it is the intention of this chapter to review assessment in science and the assessment standard within the National Curriculum Statement. This integration is expected to improve learning and teaching by establishing mutual support among various components, such as the intended, perceived, implemented and achieved curriculum, opportunities to learn, school-based assessment and state-mandated assessment (Tamir, 1998:761).

5.2 Outcomes-Based Assessment in Sciences

Although assessment is regarded as the most important aspect of education, most science teachers look at assessment as an unpleasant task, one that unfortunately has to be done, and the quicker the better! Because of this, assessment is frequently left until the end of a unit or lesson. Then some kind of test is hastily developed and given to the learners. Sometimes, the test fits what was taught, some other times it is far removed from what has been taught. However absurd, this happens frequently. These test results are then often put into the form of grades and given to the students, mainly for ranking students and providing reports to parents. The teacher relaxes in the knowledge that the students have been tested, at least for another month or so. Happily there is much more to assessment than this. With careful planning and sufficient time to prepare the form of assessment, evaluation can be an integral part of the teaching and learning process (Trowbridge et al., 2004:245).

Benjamin Bloom (1970:31, as quoted by Payne, 2003:6) summarises the process of educational assessment as follows: “Assessment characteristically begins with an analysis of the criterion and the environment in which the individual lives, learns, and works. It attempts to determine the psychological pressures the environment creates, the roles expected, and the demands and pressures – their hierarchical arrangement, consistency, as well as conflict. It then proceeds to the determination of the kinds of evidence that are appropriate about the individuals who are placed in this environment, such as their relevant strengths and weaknesses, their needs and personality characteristics, their skills and ability”. It involves a variety of data-gathering techniques, such as observations, stress interviews, performance measures, group discussions, individual and group tasks, peer ratings, projective techniques, and various kinds of structured tests (Payne, 2003:6).

Assessment concerns itself with the totality of the educational setting and is the more inclusive term, that is, it subsumes measurement and evaluation (Payne, 2003:6). It usually includes a task for students to perform and a rubric according to which their performance on the task will be evaluated (Mueller, 2003:1). While others define assessment as involving learners in the manipulation of materials and equipment to generate a response, performance assessment refers to any assessment task in which learners are required to perform the assessment task. Characteristics of good assessment tasks, amongst others, include the following: open-ended response tasks that provide learners the opportunity to generate a number of acceptable responses; closed-ended response tasks where learners provide a single best answer; and practical tasks where learners manipulate materials and use equipment to generate a response. All may be used to assess inquiry and science process skills and conceptual understanding (Shepardson, 2001:24).

The development of adequate assessment methods is of utmost importance because of the strong relationship that exists between learning and assessment. Alderson and Wall (1993) and Prodromou (1995, as quoted by Baartman et al., 2006:154) have described this as the "washback effect" or "backwash effect": what is assessed strongly influences what is learned. If assessment only measures factual knowledge, then, learners will concentrate primarily on learning facts (Baartman et al., 2006:154). Authors quoted by Baartman et al. (2006) (e.g. Biggs, 1996; Dochy, Moerkerke and Martens, 1996; Tillema, Kessels & Meijers, 2000), see the linking of assessment to instruction as the cornerstone of success for the implementation of competency based education or Outcomes-Based Education. The underlying premise is that assessment should be used mainly to promote learner learning and improve instruction (Stern & Ahlgren, 2002:891). Some (Anon., 1998b:77) find assessment and learning to be two sides of the same coin. The methods used to collect educational data define in measurable terms what teachers should teach and what learners should learn. They further define when learners engage in an assessment exercise, and what they should learn from it.

Biggs (1996, 1999, as in Bartman et al., 2006:154) calls this linking constructive alignment. Constructive alignment does not prescribe a specific type of instruction, learning and assessment, but only prescribes that the three must be well aligned. Such an alignment exists, for example, for traditional teaching aimed at knowledge transfer, rote learning and factual knowledge tests. However, since learning and instruction are increasingly competency based, this alignment is endangered because the development of adequate assessment methods appears to be lagging behind. If instruction and learning are based on acquiring competencies, then constructive alignment implies that assessment must also be competency based (Baartman et al., 2006:154).

One of the problem areas within the traditional education model in South Africa, often highlighted by educationists, was the assessment system (Hughes, 1996; Puhl 1997) (as quoted by Dreyer, 2000:267). Dreyer (2000:267) found the following aspects to be singled out for criticism:

- Learner achievement was measured in terms of symbols and percentages that are often no real indication of actual performance.

- Learner achievement was compared to that of the other learners (i.e. norm-referenced) and led to excessive competition.
- Competitiveness and once-off nature of the final examination have led to learners experience stress and frustration.
- The stress of an exam can cause the learner to drop out, to break down, and even to commit suicide.
- Teachers have tended to "exam-teach" at the expense of broader educational objectives.
- Teachers help learners to "spot" questions, study model answers.
- Past examination papers replace the curriculum, driving the teaching and learning process.
- Tests and exams dominate assessment throughout the school.
- Quoting Desforges (1989:35) Dreyer (2000:267) states that: "If teachers, in a well-meaning spirit, lead their learners by the nose through the demands of an assessment system, learners will fail to learn how to learn independently. Instead, some will learn a whole range of 'smart Alec' tricks for survival. Many have learnt how to despair (Dreyer, 2000)".

This can be compared with following accounts of the operation of the examination system in a developing country, written by a visitor who (Black, 1995:257) spent several months there studying the system. The effect of the examination on the schools is by common consent disastrous. In the words of a school teacher who had recently returned from another country, "It hinders true development and deprives children of both understanding and enjoyment." Or, as a secondary head put it, "Five years of cramming stifles the eagerness to find out […] when boys come here they are no longer interested in work (Black, 1995:257)".

Thus, those who propose changes in assessment rest their argument on the premise that what we assess and how we assess it reflects both what is taught and the way it is taught (Barth & Mitchell, 1992:14; Puhl, 1997:1; RSA, 1998:3) (as quoted by Dreyer, 2000). Dreyer (2000) goes on to quote Pahad, (1997); Puhl, (1997); and DoE, (1998a), who argue that the goal of assessment should be to have learners who create, reflect, solve problems, collect and use information, and formulate interesting and worthwhile questions. Therefore, our assessment must measure the extent to which learners have mastered these types of knowledge and skills. By requiring our learners to complete high quality performance tasks we have the potential to bring about significant and positive changes in teaching and learning (Dreyer, 2000).

Reiterated by the South African National Department of Education, it is envisaged that what good assessment should be and do must amongst others:

- be understood by the learner and by the broader public;
- be clearly focused;

- be integrated with teaching and learning;
- be based on the pre-set criteria of the Assessment Standards;
- allow for expanded opportunities for learners;
- be learner-paced and fair; and
- be flexible;
- use a variety of instruments;
- use a variety of methods (DoE, 2003(a):57).

This view of assessment places greater confidence in the results of assessment procedures that sample an assortment of variables using diverse data-collection methods, rather than the more traditional sampling of one variable by a single method. Thus, all aspects of science achievement – the ability to inquire, scientific understanding of the natural world, understanding of the nature, and utility of science – are measured using multiple methods such as performances and portfolios, as well as conventional paper-and-pencil tests (Anon., 1998b:78).

This means that good assessment tasks need to be developed.

5.3 Developing a good OBA tasks

For an educator to development a good Outcomes-Based Assessment task, the educator must involve, amongst others, the following:

- identify the curriculum and instructional goals,
- state the purpose of the assessment,
- identify the task format to be used,
- write the task,
- develop the implementation procedure,
- construct the scoring system (guide or rubric),
- trial test the task,
- analyse learner responses, and
- revise the task.

The first step in the development of good assessment task is to identify the curricular and instructional goals that the task should assess (Shepardson, 2001:24). It should reflect the goals and experience of the curriculum to such an extent that when the learners study towards the tests, they are also doing what is intended for their school studies (Tamir, 2003:766). This ensures the alignment between the curricular and instructional goals and the assessment task. Furthermore, it ensures that the assessment task addresses the science domains: content knowledge, inquiry and science process skills, science attitudes, personal and cooperative skills, and thinking and reasoning skills.

The second step is to state the purpose of the assessment task. The purposes of assessment go beyond simply evaluating and grading learners (refer to paragraph 2.4). In a nutshell, the purpose of an assessment task may be to inform pedagogy, to diagnose learner difficulties or understanding, to measure learner achievement or learning, or to provide feedback to learners (Shepardson, 2001:24).

After specifying the purpose of the task, the next step is to identify the assessment format to be used. The task format selected should be such that the assessment system reflects a variety of task formats and provide multiple measures. The task may contain the following sections depending on the task format: the setting or context, the prompt, and directions for completing the task. The task design comprises these three dimensions. The setting or context provides learners with the necessary background information for understanding and completing the task. The prompt states what learners have to do to complete the task, guiding learners in their thinking and actions. Directions provide learners with additional information about how to complete the task, what materials or equipment they can use, or how they should respond to the prompt. The task may require learners to respond by writing a short brief, constructing a model, creating a Power Point presentation, or making an oral presentation. These task dimensions need to be considered in writing the task as well as the science domains or learner traits to be assessed. The task context, prompt, and directions must all be aligned with the science domains to be assessed, and it must be ascertained that the tasks will reliably measure what is intended (Shepardson, 2001:25).

An educator's assessment of learners' performances must have a great degree of reliability. This means that educators' judgements of learners' competencies should be generalised across different times, assessment items and markers. The judgements made through assessment should also show a great degree of validity; that is, they should be made on the aspects of learning that were assessed. Each assessment cannot be totally valid or reliable by itself, and therefore decisions on learner progress must be based on more than one assessment (DoE, 2003a:57).

Cronbach (1960), (as in Payne, 2003:6) noted three principal features of assessment, and they are as follows:

- (1) the use of a variety of techniques,
- (2) reliance on observation in structured and unstructured situations, and
- (3) integration of information.

These characteristics and the English definition of assessment (paragraph 2.2) are readily applicable to a classroom situation. Teachers are, of course, concerned with the totality of an individual's characteristics – cognitive, affective, and psychomotor. A classroom setting is social and provides both structured and unstructured phases. Obviously, a variety of instruments are needed to measure a myriad of relevant variables. The objective of educational assessment is to appraising the totality of the student, his or her environment, and his or her accomplishments (Payne, 2003:6).

The most important direct influence on learners' day-to-day learning is the classroom assessment. Teacher-designed tests for an individual class can serve the needs of individual learners to a greater degree than the state-wide or nationwide standardized skills tests. However, research suggests that teacher-made tests are often as limited in measuring learner thinking as their standardized counterparts (Stiggings & Conklik, 1992) (as quoted by Anon., 1998a:2). Some (Anon, 1998a) critics feel that teacher-made tests are mostly short-answer or matching items that place far more emphasis on learner recall than learner thinking ability. Secondly, evidence suggests that because teachers do not receive proper training in effective assessment methods, they tend not to change the methods they use as assessment needs change. Different assessments are needed to measure performance, effort, and achievement, for instance, but teachers tend to use the same type of assessment to measure all three.

Teachers often use the assessments that are found at the end of textbook chapters or are included in the textbook publisher's package due to time constraints (Anon, 1998a). Many of these assessment packages contain mainly short answer questions that require only low-level thinking skills and simple recall of factual knowledge. However, many newer science and mathematics curriculum projects and textbooks include assessments that address an array of valued outcomes and show promise for improving classroom assessment if teachers are trained in using them (Anon, 1998a). Even if teachers receive the training, time, and resources that would allow them to broaden their science assessment practice, learners themselves may be the barriers. Learners, especially those in high school or secondary school who have become test-wise, sometimes object to the more labour-intensive format of assessment that require performing tasks, answering essay questions, or providing possible solutions to open-ended problems (Anon., 1998a:2).

Another problem is that the development of assessment methods to adequately assess the acquisition of competencies is hindered because it is not clear what the requirements for these kinds of assessment are. Do traditional criteria for testing also apply to recently developed assessment methods, or are other complementary or supplementary criteria needed (Baartman et al., 2006:154)? Assessment of competency is very complex, mainly due to the fact that a competency comprises a complex integration of knowledge, skills and attitudes (Merriënboer, Van der Klink, & Hendricks, 2002) (as quoted by Baartman et al., 2006:154). Assessing competencies is such a complex endeavour, and therefore it seems to be impossible to assess competency using only one assessment method. Baartman et al., (2006:154) quote Birenbaum, (1996, 2003) indicating that the past ten years have been characterised by a transition from a testing culture to an assessment culture, with the concomitant development of new assessment methods promising a panacea for the determination of competencies (Baartman et al., 2006:154).

To reiterate what Shepardson (2001) indicated on paragraph 5.3 above, de Lange (1999:10) came up with the following list of principles for classroom assessment that reflects on the standards of assessment:

- The main purpose of classroom assessment is to improve learning (Gronlund, 1968; de Lange, 1987; Black & Wiliam, 1998; and many others) (as quoted by de Lange 1999:10).
- The science is embedded in worthwhile (engaging, educational, authentic) problems that are part of students' real world.
- Methods of assessment should be such that they enable learners to reveal what they know, rather than what they do not know (Cockroft, 1982) (as quoted by de Lange 1999:10).
- A balanced assessment plan should include multiple and varied opportunities (formats) for learners to display and document their achievements (Wiggins, 1992) (as quoted by de Lange 1999:10).
- Tasks should operationalize all the goals of the curricula (not just the "lower" ones). Helpful tools to achieve this are performance standards, including indications of the different levels of scientific thinking (de Lange, 1987) (as quoted by de Lange 1999:10).
- Grading criteria should be public and consistently applied, and should include examples of earlier grading showing exemplary work and work that is less exemplary.
- The assessment process, including scoring and grading, should be open to learners.
- Learners should have opportunities to receive genuine feedback on their work.
- The quality of a task is not defined by its accessibility to objective scoring, reliability, or validity in the traditional sense, but by its authenticity, fairness, and the extent to which it meets the above principles (de Lange, 1987) (as quoted by de Lange 1999:10).

5.3.1 Comparison between authentic and traditional assessment

5.3.1.1 Traditional assessment

Traditional assessment refers to the forced-choice measures of multiple tests, fill-in-the-blanks, true-false, matching and the like that have been and remain so common in education. According to Mueller (2003:2), learners typically select an answer or recall information to complete the assessment. These tests may be standardised or teacher created. They may be administered locally or nationally.

Behind traditional and authentic assessments is a belief that the primary mission of schools is to help develop productive citizens. That is the essence of most mission statements. From this common beginning, the two perspectives on assessment diverge. Essentially, traditional assessment is grounded in an educational philosophy that adopts the following reasoning and practice (Mueller, 2003:2):

1. A school's mission is to develop productive citizens.
2. To be a productive citizen an individual must possess a certain body of knowledge and skills.
3. Therefore, schools must teach this body of knowledge and skills.
4. To determine if it is successful, the school must then test learners to see if they have acquired the knowledge and skills.

In the traditional assessment model, the curriculum drives assessment. The body of the knowledge is determined first. That knowledge becomes the curriculum that is delivered. Subsequently, the assessments are developed and administered to determine if the acquisition of the curriculum occurred (Mueller, 2003:2).

5.3.1.2 Authentic assessment

An important shift is toward "authentic assessment." This movement calls for exercises that closely approximate the intended outcomes of science education (Anon., 1998:78). Authentic assessment is a form of assessment in which learners are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skill (Mueller, 2003:1). Mueller also gave the definitions of authentic assessment by Wiggins and Stiggins. According to Wiggins (as quoted by Mueller, 2003:1), authentic assessment refers to: "… engaging and worthy problems or questions of importance in which learners must use knowledge to fashion performances effectively and creatively. The tasks are either replicas of or analogous to the kinds of problems faced by adult citizens and consumers or professionals in the field." Stiggins (as quoted by Mueller, 2003:1) finds authentic assessment a performance assessment that call upon the examinees to demonstrate specific skills and competencies, that is, to apply the skills and knowledge they have mastered. It may refer to assessment tasks that resemble reading and writing in the real world and in school. In this case, it assesses many different kinds of literacy abilities in contexts that closely resemble the actual situations in which those abilities are used (Anon., 1997:1).

In contrast, authentic assessment springs from the following reasoning and practice:

1. A school mission is to develop productive citizens.
2. To be a productive citizen, an individual must be capable of performing meaningful tasks in the real world.

3. Therefore, schools must help learners become proficient at performing the tasks they will encounter when they graduate.
4. To determine if it is successful, the school must then ask learners to perform meaningful tasks that replicate real world challenges to see if learners are capable of doing so (Mueller, 2003:3).

Thus, authentic assessment drives the curriculum. That is, teachers first determine the tasks that learners will perform to demonstrate their mastery, and then a curriculum is developed that will enable learners to perform those tasks well, which would include the acquisition of essential knowledge and skills. This has been referred to as planning backwards (Mueller, 2003:2).

Assessment is authentic when it directly examines learner performance on worthy intellectual tasks. Execution of authentic tasks is a useful, engaging activity in itself. It becomes an "episode of learning" for the learners (Wolf, 1989) (as quoted by Anon., 1997:1). From the teacher's perspective, teaching such tasks guarantees that teachers are concentrating on worthwhile skills and strategies (Wiggins, 1989) (as quoted by Anon., 1997:1). Learners are learning and practicing how to apply important knowledge and skills for the authentic purposes. They should not simply recall information (Anon., 1997:1).

Compared to traditional assessment, performance assessment, by contrast, relies on indirect or proxy "items" – efficient, simplistic substitutes from which we think valid inferences can be made about the student's performance at those valued challenges (Wiggins, 1990, 1). It is a term that is commonly used in place of, or with, authentic assessment. Performance assessment requires learners to demonstrate their knowledge, skills, and strategies by creating a response or a product (Rudner & Boston, 1994; Wiggins 1989) (as quoted by Anon., 1997:1). Rather than choosing from several multiple-choice options, learners might demonstrate their abilities by conducting research and writing a report, developing an analysis, making a deduction. The format for performance assessment, range from relatively short answers to long term projects that require learners to present or demonstrate their work. These performances often require learners to engage in higher-order thinking and to integrate many subject skills. Consequently, some performance assessments are longer and more complex than traditional assessments (Anon., 1997:1).

Authentic assessment requires learners to be effective performers with acquired knowledge, while traditional tests tend to reveal only whether the student can recognise, recall or "plug in" what was learned out of context. This may be as problematic as inferring driving or teaching ability from written tests alone (Wiggins, 1990, 1).

As assessment data informs a variety of decisions, including the tracking of learners, the determination of grades, instructional evaluation and curricular choices, placement in special programs, and progression in grade sequence, assessment tasks must be of good quality. Thus, there are certain principles that, though sometimes ignored, are paramount and relevant to any discussion of assessment. These principles are concerned with the validity of assessment, which is the primary and overarching consideration in evaluating the quality of an assessment (Klassen, 2006:841).

5.4 Validity

Another conceptual shift within the educational measurement area that has significant implications for science assessment involves validity. Validity must be concerned not only with the technical quality of educational data, but also with the social and educational consequences of data interpretation (Anon., 1998:780). Most of those who write about assessment of learning claim that validity and reliability are the two most important characteristics of good assessment items or tasks. It is therefore vital for teachers (including teachers in higher education) to be able to use these concepts appropriately to guide assessment practices. Application of these concepts depends upon a deep understanding of their meaning and implications (Killen, 2003:1). In the following paragraphs, the four major assessment principles of inference, generalisability, consequences of assessment and social values concerned with validity and reliability, will be reviewed.

5.4.1 The concept validity

While the concept of reliability has remained reasonably static for the past half century, the concept of validity has evolved considerably. The 1950's view that a valid test is one that actually measures what you want it to measure has developed into the 1990s view that "validity is an integrated evaluative judgement of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment" (Messick, 1989a:13) (as quoted by Killen, 2003:1 and Klassen, 2006:841). Airasian (2001:423) expresses validity as "the degree to which assessment information permits correct interpretations of the desired kind" (as quoted by Killen, 2003:1).

The difference is not in just one detail. It involves is a significant change in emphasis from validity as a property of a test item or assessment task to validity as a value judgement about inferences and actions made as a result of assessment. There is a change in focus from the question "Is my test valid?" to the question "Am I making justifiable inferences and decisions on the basis of the assessment evidence I have gathered?" This represents an important shift in responsibility for validity from the test constructor to the test user (Killen, 2003:1).

It should then be emphasised that a broad concept of validity is central to the design of any assessment system. In recent comprehensive treatment, earlier sets of definitions have been subsumed into a single statement (Black, 2003:814):

> "Validity is an integrated evaluation judgement of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment (Messick, 1989:130 (as quoted by Black, 2003:814; Klassen, 2006:841 and Killen, 2003:1)".

Messick (1989a:13, as quoted by Klassen, 2006:841) stresses that validity is a unitary concept. The many aspects of validity are just that – aspects of validity, not kinds of validity. The most fundamental aspect of validity is construct validity, whether a test actually measures what it purports to measure (Klassen, 2006:841). The implications of this redefinition are described within the framework of Outcomes-Based Education (Killen, 2003:1).

5.4.1.1 The need for validity

There are many reasons why we assess learners, as indicated in the previous and present chapter. In more recent years the purposes of assessment have been broadened to include diagnosis (e.g. determining why a learner has difficulty reading), grading (e.g., grading students in a university subject), progression (e.g., deciding whether individual learners are ready to progress to the next year of school), and instructional improvement (e.g., determining the effectiveness of particular instructional strategies). In all these applications of assessment, there are some important common threads. The first is a belief that there is something (intelligence, aptitude for a particular job, scholarly accomplishment, programme quality and so on) that can be measured. The second is a belief that these factors can be measured in such a way that distinctions can be made between how much of it is possessed by different individuals, by different groups of learners or by different instructional programmes. Implicit to these beliefs is the idea that measurement can provide information that is accurate and worthwhile – information that can justifiably be used for making important decisions. The concept reliability and validity in educational measurement were developed in an attempt to describe just how worthwhile the information from a particular measurement might be and to suggest what might be done to increase the trustworthiness of measurement procedures (Killen, 2003:2).

Killen (2003:2) finds that many books on assessment written for teachers define validity rather loosely. For example, Hill (1981:22) defines validity as the extent to which “a test measures what it is meant to measure” and Brady and Kennedy (2001:55) put it as “when assessment tasks measure what teachers want them to measure, they are said to be valid tasks”. Killen (2003:2) finds that there is some appeal in the simplicity of this definition, particularly in Outcomes-Based Education where teachers can ask whether “is this item testing the outcome I want to test?” This simple view of validity as an inherent property of an item or test, can be misleading and counter-productive (Killen, 2003:2).

Even though there have been a number of significant stages in the evolution of the concept validity, it seems that the ideas emerging in each new stage have not always resulted in the majority of teachers changing their assessment practices. Killen (2003:3) discovered considerable evidence that many current assessment practices are still guided by vague conceptions of validity that are based on measurement theories from the 1950s. This, according to Killen (2003:3), has important consequences for the quality of assessment practices and for the assessment-based decisions that teachers make. Outdated conceptions of validity have the potential to mislead teachers, including those who are trying to implement Outcomes-Based Education in South Africa (Killen, 2003:3).

There has been development from the idea that a test is valid “for anything with which it correlates” (Guildford in Messick 1989a:18, as quoted by Killen, 2003:3) to the idea that there is a finite number of types of validity (Gronlund, 1982, as quoted by Killen, 2003:3) to the idea that validity is a unitary concept (Messick, 19989a). This change has been a shift from prediction to explanation, from the idea that correlations between test scores and some criterion are important, to the idea that importance lies in the way in which test scores can be interpreted to provide information about some underlying construct. This change in focus emphasises that when these interpretations do not have a sound theoretical and empirical basis, their utility, relevance and value must be questioned (Killen, 2003:3).

Killen (2003:3) realised that some of the textbooks written for teachers and teacher education students continue to emphasise the intermediate stage of validity’s historical development – the stage that conceived validity as having three distinct types, namely content validity, predictive and concurrent criterion validity, and construct validity (e.g. Brady & Kennedy, 2001) (as quoted by Killen, 2003:3). According to Messick (1989a:17, as quoted by Killen, 2003:3) content validity is an indication of how relevant the content of a test or assessment task is, and how representative it is of the domain that it is purported to be tested. It is essentially this concept of content validity that leads to claims such as “validity defines whether a test or item measures whatever it has to measure” (Van der Horst & McDonald, 2001:185, as quoted by Killen, 2003:3). This simplified approach to validity

(Killen, 2003:3) also overlooks the fact that determining what a test measures requires more than considering relevance and representativeness.

One way to address this shortcoming is to consider criterion-related validity. The criterion-related validity of a test is determined by comparing the test scores with one or more external variables (called criteria) that are considered to provide a direct measure of the behaviour or characteristic in question (Messick, 1989a:17, as quoted by Killen, 2003:3). This is generally not the situation in classroom assessment where it is more likely that individual teachers develop tests that are not correlated with any external, direct measure of whatever they are trying to assess. Therefore, for normal testing purposes in classrooms, this means that the predictive criterion validity of teacher-developed tests cannot be determined in a timeframe that makes the exercise worthwhile. Thus, criterion-related validity that is concerned just with specific test-criterion correlation is not a particularly useful concept for classroom teachers (Killen, 2003:4).

This then leads to a consideration of construct validity. Constructs are theoretical conceptual frameworks for describing human characteristics, behaviours or groups of abilities. For example, reasoning ability, self-esteem and communications style are hypothetical constructs. Construct validity is essentially concerned with investigating the meaning of test scores. It is based on the idea that a score on a well-constructed test can be taken as one (of possibly many) indicators of the construct of interest. For example, a test might provide a strong indication of a learner’s mathematical reasoning ability (the construct for interest), but it would be just one of many such indicators. Likewise, the test might be a strong indicator of other constructs (such as reading ability) (Killen, 2003:4).

The practice of thinking about different aspects of validity as separate entities was common until the mid-1980s and has persisted in many modern texts (Killen, 2003:4). Brady and Kennedy (2001) (as quoted by Killen, 2003:4) distinguish between five separate aspects of validity (content validity, construct validity, consequential validity, concurrent validity and predictive validity). The problem here, according to Killen (2003:4), is not that validity is considered multi-dimensional, but that the *gestalt* is being in the detail. It is more productive to think of validity as a unitary concept, but not as a simplistic one.

Most important, no matter how we try to distinguish between different types of validity, it is inappropriate to say that a test item or assessment task is valid in some absolute sense. Rather, we should think of validity in terms of the definition provided by the American Education Research Association (AERA), American Psychological Association (APA) and the National Council on Measurement in Education (NCME) (1985, 94) (as quoted by Killen, 2003:4), namely that validity is a unitary concept that refers to the “degree to which a certain inference from a test is appropriate and meaningful”. From this perspective, assessment tasks themselves can never be valid or invalid, it is the assessment-based inferences we make that are valid or invalid (Gitomer & Duschl, 2003:792 and Killen, 2003:5). This distinction is important because it addresses one of the fundamental challenges of Outcomes-Based Education, the challenge of developing assessment instruments that allow teachers to draw valid inferences about the extent to which learners have achieved curriculum outcomes (Killen, 2003:5).

5.4.1.2 Inference

Inference refers to the reasoning involved in drawing a conclusion or making a logical judgement on the basis of circumstantial evidence and prior conclusions rather than on the basis of direct observation. Thus, validity resides in the interpretation of information provided by the assessment, not in the assessment itself. Put simply (Gitomer & Duschl, 2003:792), there is no such thing as a “valid test”. There are interpretations of test information that are more or less valid. As an example, the Scholastic Aptitude Test (SAT), which is used in the USA as a predictor of an individual’s performance in post-secondary education, provides valid scores if we want to make inferences about being a successful college student. However, SAT scores do not allow for valid inferences about creative or artistic abilities or oral communication skills (Gitomer & Duschl, 2003:792). Thus, scores from the SAT, as well as those from any assessment, are not valid in any absolute sense (Gitomer & Duschl, 2003:792 and Killen, 2003:4).

In education, we often see invalid interpretations of test scores that can otherwise be used to support valid interpretations. Good assessment, then, requires valid inferences. One research challenge in getting teachers and students to conduct formative assessment is determining what valid inferences one can and should make. Inferences are made from assessment about characteristics, most often student characteristics, which are not directly observable. When a student correctly answers ten items from a multiple-choice test, the only observables are the ten answer choices, yet a typical teacher will make two inferences. One is that the ten choices reflect a certain level of understanding of the content addressed by the items. The second inference is that there is a high likelihood that the student understands all of the content addressed in this curricular segment, even though the test is only a small sampling of the germane topics and concepts (Gitomer & Duschl, 2006:793).

A critical implication of Messick’s (1989:26) view about construct validation (as quoted by Gitomer & Duschl, 2003:794), is that not only must we examine learner evidence within existing theoretical frameworks, but the frameworks themselves must be subject to examination and modification.

Interpretations of learner performance do not have meaning unless the guiding assumptions and beliefs that underlie the assessment are explicitly understood (Gitomer & Duschl, 2003:794).

5.4.1.3 Generalisability

A second principle of assessment validity is that inferences and interpretations generalise beyond a specific assessment task. For some assessment, there is no need to generalise beyond performance on the assessment. For most educational assessments, however, there is a need to generalise. We assume that assessment tasks are sensitive to learners' skills and understanding that extend beyond a given task and moment. The assessment tasks are selected because they are representative of a class or tasks that allow for inferences of abstracted concepts such as 'reading ability'. There is an expectation that an inference about learner ability will not change significantly if we replace tasks or if we assess at different times (Gitomer & Duschl, 2003:794). According to Shavelson and Webb (1991) (as quoted by Gitomer & Duschl, 2003:794), when interpretations of learner capability are not generalisable between tasks that purportedly assess the same learner abilities, then, the validity of the assessment is questioned.

5.4.1.4 Consequences of assessment

Gitomer and Duschl (2003:794) realised that the validity of assessment has been considered only in terms of construct validity, in other words how well the evidence supports the interpretations made on the basis of the assessment. The third principle of validity is consequential validity. This principle arose after Messick raised the prominence of a second consideration of validity, the consequences of an assessment. Therefore, the validity of any assessment must be considered in terms of both intended and unintended consequences of the assessment. Frederiksen and Collins (1989) (as quoted by Gitomer & Duschl, 2003:795), introduced the concept of systematic validity, arguing that the validity of any assessment must be considered in terms of how it facilitates educational practices that promote desired learning. The third principle of assessment emphasised here is that assessment validity requires attention to both an assessment's construct validity and consequences of its use. Attending to only one of these validity aspects can lead to poor assessment and educational practice (Gitomer & Duschl, 2003:795).

5.4.1.5 Social values

The entire process of assessment is a reflection of social values. Values influence how assessments are used, what is assessed, and how interpretations are reported. Even the most "objective" assessment is only objective in terms of how it is scored. The selection of items and the decisions to design an "objective" test are choices that reflect what those who make, administer and use the assessments value. Thus, any discussion of science assessment must begin with an understanding of the social values that surround it (Gitomer & Duschl, 2003:795).

A good assessment instrument provides accurate estimates of student performance and enables teachers or other decision makers to make appropriate decisions. The concept of test validity captures these essential characteristics and the extent that an assessment actually measures what it is intended to measure, and permits appropriate generalizations about the student's skills and abilities. For example, a ten-item addition/subtraction test might be administered to a student who answers nine items correctly. If the test is valid, we can safely generalise that the student will likely do as well on similar items not included in the test. The results of a good test or assessment, in short, represents something beyond how student perform on a certain task or particular set of items; they represent how a student performs on the objective that those items intend to assess (Dietel et al., 1991:3).

Measurement experts agree that test validity is tied to the purpose for which an assessment is used. Thus, a test might be valid for one purpose, but inappropriate for other purposes. For example, our mathematics test might be appropriate for assessing students' mastery of addition and subtraction facts, but inappropriate for identifying students who are gifted in mathematics. Evidence of validity needs to be gathered for each purpose for which an assessment is used (Dietel et al., 1991:3).

Cross (1998) hypothesises that if the purpose of assessment is to improve the quality of learners' learning, then the following premises should prevail:

- The assessment must involve directly those who are actually engaged in teaching and learning, namely teachers and learners.
- If assessment is to make a difference, it must address the questions that are of interest to teachers. Specifically, teachers must formulate their own assessment questions and designs to provide the type of information that will inform their teaching.
- Feedback from assessment to the people who can do something about it, namely teachers and learners, must be timely and accurate (Cross, 1998:39).

5.4.2 Outcomes-Based Validity

The ideas explored in paragraph 5.4.1 provide a sound basis for considering how validity could be conceptualised in an Outcomes-Based Education system. This paragraph attempts to give perspectives of validity in Outcomes-Based Education as redefined by Killen (2003). Killen finds the general principle of seeking content-related evidence, criterion-related evidence and construct-related evidence to support claims that the inferences drawn from assessment results are valid and appropriate. However, in Outcomes-Based Education there are some aspects of assessment that need to be addressed before we can claim to be making valid inferences about learner learning.

The definition of content-related evidence of validity in the 1985 Standards of the American Educational Research Association, American Psychological Association and the National Council on Measurement in Education gives the impression that learning should be focused primarily on the accumulation of knowledge (content). In Outcomes-Based Education, it would be more appropriate to require outcome-related evidence of validity, that is, evidence that we are drawing valid inferences about achievement of outcomes, rather than about learning of content. Quoting Popham's (1990) suggestions about quantifying content-related evidence of validity, Killen (2003:9) thinks of outcome-related evidence of validity as having two components, relevance and outcome coverage. That is (Killen, 2003:9), we could determine whether or not each assessment item requires that a learner demonstrates one or more relevant outcomes and we could determine the extent to which the total assessment task or programme addresses an appropriately comprehensive sample of outcomes (Killen, 2003:9).

According to Killen (2003:9), alignment between outcomes and assessment is the foundation for drawing valid inferences about student learning, but it does not guarantee that valid inferences will be drawn. The evidence that the teacher has drawn valid inferences about learner's abilities to demonstrate the learning that is explicitly or implicitly described by the outcomes is second to consider under outcomes-related evidence of validity. This requires evidence that the teacher has: 1) taken into account the characteristics of the learners (e.g., their language proficiency); 2) interpreted the student's responses appropriately; 3) recognised the full range of abilities that the task is assessing; and 4) not extrapolated from the results to draw inferences about learning that have not been tested.

In Outcomes-Based Education it is often said that the principal reason for assessment is so that we will know whether or not learners have achieved the outcomes we wanted them to achieve. This view of assessment is unfortunate because it can mislead teachers into thinking that it is possible to make clear distinctions between those learners who have achieved certain outcomes and those who have not (Killen, 2003:10). Killen (2003:10) finds this view to be the result of narrow interpretation of Spady's (1994) definition of OBE (paragraph 4.3.1).

This definition is based on the implicit assumptions that someone can determine which things are: "essential for all learners to be able to do" and that it is possible to achieve these things through appropriate classroom practices. Most significantly, it also implies that it is possible to determine in some objective way whether or not learners have achieved whatever outcomes were deemed to be important (Killen, 2003:10). This view, coupled with Spady's (1994) recommendation that outcomes should always contain an 'action verb', often leads to the assumption that assessment decisions can be reduced to placing learners into categories such as "achieved/not achieved" or "exceeded/satisfied/partially satisfied/not satisfied" (DoE, 2002) for each outcome.

To overcome this problem, it is necessary to think of assessment as the process of determining how well learners are able to demonstrate what they have learned, rather than trying to determine in some categorical sense which learners have or have not learned. According to Killen (2003), if this approach is coupled with acceptance of the idea that outcomes can legitimately be expressed in terms of "understanding" (Van Niekerk & Killen, 2000) (as quoted by Killen, 2003:10) and not just in the behavioural terms recommended by Spady (1994) (as quoted by Killen, 2003:10), the foundation is set for valid inferences to be drawn about learners' learning. It changes our focus from asking, "How many questions can the learner answer?" or "Which skills can the learner demonstrate?" to "How well does the learner answer questions?" and "How expertly can the learner demonstrate a particular skill?" Understanding (rather than memorisation), creativity (rather than reproduction), diversity (rather than conformity), initiative (rather than compliance) and challenge (rather than blind acceptance) become the yardsticks by which we try to measure, describe and report learner learning.

When the above approach is adopted, it is not appropriate to think of an assessment task *per se* as valid. The tasks will deliberately be designed to evoke responses that are indicative of each learner's level of understanding; they will not do this equally well for all learners. Therefore, teachers will need to focus on the extent to which a particular assessment task enables learners to demonstrate their understanding and, most importantly, will have to consider the extent to which the available evidence can support legitimate inferences about the learning of each learner. The implications of this new focus are quite significant (Killen, 2003:10).

It is important to clarify what it means to learn and understand things in the subject area in which the assessment will be grounded. Killen (2003) simplifies this by putting it this way: "you cannot assess what you cannot define." He further indicates that you cannot draw valid inferences about learning that has not been assessed in appropriate ways. When we attempt to define what we want learners to learn, we may decide that understanding is the capacity to use explanatory concepts creatively, or the capacity to think logically, or the capacity to tackle new problems, or the ability to re-interpret objective knowledge, to mention just a few. The implications for assessment should not be concerned with the memorisation and reproduction of voluminous amounts of information, but rather with "an appreciation of the nature of the 'object knowledge' and an ability to construct and defend the particular arguments that constitute the individual's interpretive perspective". This view leads to the formulation of outcomes such as "Learners will be able to develop and defend a personal interpretation of the concept of postmodernism in literature". Outcomes such as this call for assessment tasks that will produce qualitative rather than categorical evidence of learner achievement.

It becomes obvious that there is not a clear cut-off point between achieving/not achieving the outcome. We are no longer faced with the problem of inferring whether or not a learner has achieved a particular outcome. Instead, we have the challenge of making valid inferences about how well each outcome has been achieved. Evaluation of this evidence of learning will require a high level of interpretation and subjective judgement and it is the validity of these interpretations and judgements that will have to be defended, not the validity of the questions that prompt the generation of the evidence (Killen, 2003:11). Fair inferences can be drawn from assessment results, and valid comparison can be made only when assessment data includes information on the nature of the learners, the learners' opportunities to learn the material assessed, the adequacy of resources available to the learners, and the methods of assessment. However, it must be emphasised that comparisons of individual learners, particularly norm-referenced comparisons, are not necessary in an OBE system (Killen, 2002:14).

5.5 Reliability

It should be noted that the concepts of validity and reliability in educational measurement were developed in an attempt to describe just how worthwhile the information from a particular measurement might be and to suggest what might be done to increase the trustworthiness of measurement (Killen, 2003:2). On the other hand, essential to validity is the consideration of reliability. Reliability is defined as the degree to which a test consistently measures whatever it measures. The more reliable a test is, the more confidence we can have that the scores obtained from the administration of the test are essentially the same score that would be obtained if the test is re-administered (Gay, 1996:145) (as quoted by Klassen, 2006:841).

Gipps (1994) (as quoted by Reeds; Granville; Janks; Stein; Van Zyl; & Samuel, 2003:15) defines reliability as a process that is concerned with the accuracy with which the test measures the skill or attainment it is designed to measure. The underlying reliability questions are: would an assessment produce the same or similar score on two occasions or if given by two assessors? Reliability therefore relates to consistency of pupil performance and consistency in assessing that performance: which we may term replicability and comparability (Reeds et al., 2003:15).

It is accepted as a psychometric measurement principle that without reliability there can be no validity (Moss, 1994) (as quoted by Klassen, 2006:841). *The principles of validity and reliability as they have been applied in conventional assessment cannot simply be imposed upon contextual assessment, and this is so because of basic underlying presuppositions that are different for each of the two paradigms of assessment. The latter promotes personal knowledge of the student's performance and potential on the part of the test reader, whereas the former opposes this diametrically (Moss, 1994) (as quoted by Klassen, 2006:841). In contextual assessment, it is seen as an advantage that the assessment reader knows the student well in order to make a better judgement of the student's performance (Klassen, 2006:842).

Defining the level or standard of achievement of non-trivial outcome is a complex process that can be approached in several different ways. One useful approach is to apply the Taxonomy of Learning, Teaching and Assessing by Anderson and Krathwohl (2001) (to be discussed in Chapter 8). They suggest a six-level hierarchy of cognitive (remember, understand, apply, analyse, evaluate and create) and four types of knowledge (factual, conceptual, procedural and meta-cognitive) that combine to form a two-dimensional grid onto which outcomes can be mapped. Killen (2003:11) finds that this helps to clarify the outcome and simplify the process of aligning outcomes, teaching strategies and assessment.

5.6 Standards of assessment in OBE

The first common theme of any country's education systems is that assessment systems cannot be discussed without reference to curriculum. Each state has at least one authority responsible for developing curriculum frameworks for school use. These typically provide valued outcomes, suggest resources and pedagogy, and assessment guidelines (Cumming & Maxwell, 2004:91). The idea of standards or standards of competence has been extremely influential in recent years (Jessup, 1991) (as quoted by Wolf & Cumming, 2000:216). Analysing and defining the component parts of an applied skill develops standards as they are used in daily life. Most standards are developed for vocational awards, but the approach has also been adopted for academic subjects in some cases. The standards-based approach to assessment involves comparing someone's performance with a list of clearly defined outcomes, which is what the standards effectively are (Wolf & Cumming, 2000:217).

A contrast is generally drawn with conventional assessment, which supposedly fails to tell the world very much about what someone can actually do. On conventional assessment, the argument goes, people pass because they scored 50% (or even less) on some sort of test or series of teacher-created assessments, but there is no way of saying with any confidence what they actually can do.

Standards-based assessment, by contrast, defines the outcomes to be achieved very precisely. A candidate can only be accredited with achieving an outcome when they have demonstrated their complete coverage or mastery of the topic; and only achieve an award when they have achieved every outcome (Wolf & Cumming, 2000:217).

These standards describe the knowledge, understandings and abilities that learners should develop as result of their educational experiences. They also represent one aspect of a comprehensive vision of science education, which also includes science teaching and assessment (Trowbridge et al., 2004:107). The standards developed in different countries have therefore provided what is in effect a national syllabus, or at least a national assessment schedule/policy framework, in a way that has never been attempted in the past. In most instances, each standard or unit of competence is defined in terms of the precise outcomes expected and uses performance criteria and descriptions of the range of situations to be covered (Wolf & Cumming, 2000:217).

The assessment standards provide criteria to judge progress towards the science education vision of scientific literacy for all. The standards describe the quality of assessment practices used by teachers and state and federal agencies to measure learner achievement and the opportunity provided to learners to learn science. By identifying essential characteristics of exemplary assessment practices, the standards serve as guides for developing assessment tasks, practices, and policies. These standards can be applied equally to the assessment practices both classroom assessments as well as large-scale, external assessments (Anon., 1998:75).

The content standards presented in both the National Standards and Benchmarks (Outcomes) elaborate what learners should understand and be able to do in Physical Sciences, and the personal and social context that should be considered in the design of the sciences curriculum. These standards emphasise inquiry-oriented activities, connections between sciences and technology, and the history and nature of science as learners develop an understanding of fundamental ideas and abilities in science (Trowbridge et al., 2004:107). Put differently, Physical Sciences focuses on investigating physical and chemical phenomena through scientific inquiry. By applying scientific models, theories and laws, it seeks to explain and predict events in our physical environment (DoE, 2005:7).

The curriculum is always considered to be a major determinant of achievement, and the curricular framework that is reflected internationally guides the development of achievement tests, or national consensus regarding what learners should know and do at different school levels (Zuzovsky, 2003:280). Curriculum materials need to provide guidance for teachers on how to interpret and act on student responses. Related to these characteristics, judgement about assessment in curriculum materials are made on the basis of (a) whether assessment questions and tasks appear to aim at specific benchmarks and standards, (b) whether these questions and tasks are likely to reveal what learners actually know about the content specified in benchmarks and standards (as opposed to rote memorization of these goals), and (c) whether assessment embedded in curriculum materials throughout instruction can be used for making modifications in instruction (Stern & Ahlgren, 2002:892).

Science assessment standards (e.g., prepared by the National Committee on Science Education Standards and Assessment [NCSESA]) serve as criteria against which to judge the quality of assessment practices used to determine learner attainment in science and to determine the opportunity provided to learners to learn science. These standards serve as guide and statements of principles identifying essential characteristics of exemplary assessment practices (Trowbridge et al., 2004:249).

An important assumption underlying the assessment standards is that countries and local districts can develop mechanisms to measure learners' achievement as specified in the content standards and can measure the opportunities for learning science as specified in the program and system standards. If the principles in the assessment standards are followed, the information resulting from new modes of assessment applied locally can have common meaning and value in terms of the national standards, despite the use of different assessment procedures and instruments in different localities. This contrasts with the traditional view of educational measurement that allows for comparisons only when they are based on parallel forms of the same test (Anon., 1998:78).

Trowbridge et al. (2004:249) and Anon. (1998b:78) gave the following short list of the standards prepared by National Research Council:

5.6.1 Assessment Standard A

Assessment must be consistent with the decisions they are designed to inform (Anon., 1998b:78).

It should provide for coordination with the intended purpose for which assessments are deliberately designed, and it should have explicitly stated purposes (Trowbridge et al. (2004:249).

- Assessments are deliberately designed.
- Assessments have explicitly stated purposes.
- The relationship between the decisions and the data is clear.
- Assessment procedures are internally consistent.

The essential characteristic of well-designed assessment is that the processes used to collect and interpret data are consistent with the purpose of the assessment. The match of purpose and process is achieved through thoughtful planning that is available for public review (Anon., 1998b:79)

5.6.2 Assessment Standard B

Achievement and opportunity to learn science must be assessed

Achievement data collected should focus on the science content that is most important for learners to learn. The content standards define the science all learners will come to understand. They portray the outcomes of science education as rich and varied, encompassing: the ability to inquire; knowing and understanding scientific facts, concepts, principles, laws, and theories; the ability to reason scientifically; the ability to use science to make personal decisions and to take positions on societal issues; the ability to communicate effectively about science. This assessment standard highlights the complexity of the content standards while addressing the importance of collecting data on all aspects of learner science achievement. Assessment processes that include all outcomes for student achievement must probe the extent and organization of a learner's knowledge. Rather than checking whether learners have memorized certain items of information, assessment needs to probe for a learner's understanding, reasoning, and the utilization of knowledge (Anon., 1998b:81).

When measuring learner achievement and the opportunity to learn, the data collected should focus on the science content that is most important for learners, and equal attention should be given both to opportunities to learn and to assessment of learner achievement (Trowbridge, 2004:249).

On the classroom level, some of the most powerful indicators of opportunity to learn are teachers' professional knowledge, including content knowledge, pedagogical knowledge, and understanding of learners; the extent to which content, teaching, professional development and assessment are coordinated; the time available for teachers to teach; learner inquiry; and the quality of educational materials available. The teaching and program standards define in greater detail these and other indicators of opportunity to learn (Anon., 1998b:81).

Equal attention must be given to the assessment of opportunity to learn and to the assessment of learner achievement. Learners cannot be held accountable for achievement unless they are given adequate opportunity to learn science. Therefore, achievement and opportunity to learn science must be assessed equally (Anon., 1998b:81).

5.6.3 Assessment Standard C

The technical quality of the data collected is well matched to the decisions and actions taken on the basis of its interpretation

- The feature that is claimed to be measured is actually measured. The content and form of an assessment task must be congruent with what is supposed to be measured.
- Assessment tasks are authentic.
- An individual learner's performance is similar on two or more tasks that claim to measure the same aspect of learner achievement.
- Learners have adequate opportunity to demonstrate their achievements.
- Assessment tasks and the methods of presenting them provide data that is sufficiently stable to lead to the same decisions if used at different times. Assessment tasks must be developmentally appropriate, must be set in contexts that are familiar to the learners, must not require reading skills or vocabulary that are inappropriate to the learners' grade level, and must be as free from bias as possible. Also the choice of assessment form should be consistent with what one wants to measure and to infer (Anon., 1998b and Trowbridge et al., 2004).

Standard C addresses the degree to which the data collected warrant the decisions and actions that will be based on them. The quality of the decisions and appropriateness of resulting action are limited by the quality of the data. The more serious the consequences for learners or teachers, the greater confidence those making the decisions must have in the technical quality of the data. Confidence is gauged by the quality of the assessment process and the consistency of measurement over alternative assessment processes. Judgements about confidence are based on several different indicators, some of which are indicated above (Anon., 1998b:84).

5.6.4 Assessment Standard D

Assessment practices must be fair.

- Assessment tasks must be reviewed for the use of stereotypes, for assumptions that reflect the representatives or experiences of a particular group, for language that might be offensive to a particular group, and for other features that might distract learners from the intended task.
- Large-scale assessment must use statistical techniques to identify potential bias among subgroups.

- Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, or limited English proficiency.
- Assessment tasks must be set in a variety of contexts, be engaging to learners with different interests and experiences, and must not assume the perspective or experience of a particular gender, racial, or ethnic group.

A premise of the National Science Education Standards is that all learners should have access to quality science education and should be expected to achieve scientific literacy as defined by the content standards. It follows that the processes used to assess learner achievement must be fair to all learners. This is not only an ethical requirement, but also a measurement requirement. If assessment results are more closely related to gender or ethnicity than to the preparation received or the science understanding and ability being assessed, the validity of the assessment process is questionable (Anon., 1998b:85).

5.6.5 Assessment Standard E

The inferences made from assessments about learner achievement and opportunity to learn must be sound.

- When making inferences from assessment data about learner achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.

Even when assessment is well planned and the quality of the resulting data high, the interpretations of the empirical evidence can result in quite different conclusions. Making inferences involves looking at empirical data through the lenses of theory, personal beliefs, and personal experience. Making objective inferences is extremely difficult, partly because individuals are not always aware of their assumptions. Consequently, confidence in the validity of inferences requires explicit reference to the assumptions on which those inferences are based.

Consider the following example (Anon, 1998b): if the science achievement on a large-scale assessment of a sample of learners from a certain population is high, several conclusions are possible. Learners from the population might be highly motivated; or because of excellent instruction, learners from the population might have greater opportunity to learn science; or the test might be biased in some way in favour of the learners. Little confidence can be placed in any of these conclusions without clear statements about the assumptions and a developed line of reasoning from the evidence to the conclusion. The level of confidence in conclusions is raised when those conducting assessments have been well trained in the process of making inferences from educational assessment data. Even then, the general public, as well as professionals, should demand open and understandable descriptions of how the inferences were made (Anon., 1998b:87).

An important goal of assessment is to develop self-directed learners. Thus, the learners must understand the purpose of the assessment and have opportunities for conversations and input into the assessment practices. In a nutshell, the standards include focusing on what is most important for learners to learn in science and provide data that may lead to valid inferences about learners' science attainment. The data collected should be consistent with the particular aspect of science attainment being assessed and should consider the intended use of the resulting information. Finally, equal attention should be given to the assessment of the opportunities to learn as well as to learner attainment (Trowbridge et al., 2004:249).

It should be noted that the aim of science assessment is to produce information that contributes to the teaching and learning process and assists in educational decision making, where decision makers include learners, teachers, parents and administrators. The aim of science education is to help learners become scientifically literate. This means that the individual can deal with the science involved in real world problems (i.e. nature, society, culture – including science) as needed for an individual's current and future private life (as an intelligent citizen) and occupational life (future study or work) and that the individual understands and appreciates science as a scientific discipline. The aim of a framework for science assessment is to bring the aim of classroom assessment together with the aim of science education in a seamless and coherent way, with optimal results for the teaching and learning process, and with concrete suggestions about how to carry out good classroom assessment in the classroom situation (de Lange, 1999:3).

The most widely utilised framework for evaluation of learner attainment is the taxonomy of educational objectives in the cognitive domain (Bloom, 1956) (as quoted by Tamir, 1998:765) and the affective domain (Krathwohl, Bloom & Masia, 1964) (as quoted by Tamir, 1998:765). While this framework can be and has been applied to science learners, it has been found to be too general for many purposes. The need to design specialised taxonomies for particular disciplines has been recognised by many evaluators. In fact, some have modified and adapted the general taxonomies for specialised needs, such as Klopfer's (1971) (as quoted by Tamir, 1998:765) scheme for science and Wilson's (1971) (as quoted by Tamir, 1998:765) scheme for mathematics. Others have designed entirely different taxonomies (Tamir, 1998:765).

5.7 Conclusion

According to Stark (1999:40-41), in an attempt to monitor standards (assessment standards) against national expectations (critical standards), a defensible strategy should, amongst others:

- Reflect the range of scientific concepts, skills and processes in the science curriculum;
- Acknowledge and explore the range of attainment within each stage;
- Employ different modes of assessment, including practical/performance assessment;
- Be innovative and enquiring;
- Develop tests that motivate and engage learners (both sexes);
- Identify clear and defensible interpretations of the assessment criteria;
- Establish a transparent and reasonable rationale for deriving cut-scores and statistical definitions of levels; and
- Provide explicit feedback on pupil achievement and guidance on areas of strength and weakness.

Therefore, if teachers perceive the official view of "learning science" as the ability to overtake a series of hurdles in a limited number of areas, then it is likely that the national guidelines for science will never be fully implemented. These together with the specific outcomes are discussed in detail in chapter 7, with special attention to Outcomes-Based Assessment.

The next chapter (Chapter 6) focuses on the Outcomes-Based Assessment models/modes/tools.

CHAPTER 6

The Outcomes-Based Assessment of Physical Sciences

6.1 Introduction

Diversification of modes of assessment and improved expertise among teachers in designing, developing and using appropriate assessment instruments must be given priority (RSA, 1998b:10) (as quoted by Dreyer, 2000:266). The tools and techniques of assessment traditionally used in the science classroom (e.g., multiple-choice items and norm-referenced test scores) are designed for specific purposes and are, therefore, no longer "entirely" suitable for the diverse nature of Outcomes-Based Assessment (OBA). It is no longer sufficient because the number and complexity of the assessment targets we seek information about have expanded (Hartzenberg, 2000:3).

The assessment of learning is the essential element of Outcomes-Based Education, so without valid and reliable assessment procedures the teacher will simply not know whether or not his/her learners have achieved the learning outcomes that constituted the focus of the programme, unit or lesson, and neither will the learners know whether they have learnt well. Assessment is not something that teachers should think about at the end of a unit of work, or at the end of a lesson; it must be an integral part of all planning and preparation and presentation. OBE assessment is said to be mainly formative, which means that it helps to shape or form the learner through the learning process (Van der Host & McDonald, 1997:167). This chapter will focus on different forms or types or tools of assessment. It is necessary to show that assessment takes a number of forms, that it is used for a variety of purposes, and that it must be applied in a systematic and structured way in order to be effective (Brant, Lines & Unwin, 2000:271). Outcomes-Based Assessment emphasises continuous assessment (CASS). Physical Sciences teachers need to be able to apply different tools of assessment. Thus, it is the aim of this chapter to discuss different forms of assessment that are in line with Outcomes-Based Assessment.

6.2 What should effective OBA be and do

Assessment is a strategy for measuring knowledge, behaviour or performance, and values or attitudes. It is a data-gathering strategy. The measurement or data that is gained from assessment helps the teacher to evaluate. In OBA the learning outcomes that have to be attained by the learner are very clearly defined. Through assessment, both teachers and learners are able to determine whether these outcomes have been achieved (Van der Horst & McDonald, 1997:170). OBA indicates that the learner's progress is measured against certain outcomes rather than his/her performance compared to other learners, and for this reason there is no passing or failing (Curriculum 2005 Lifelong Learning for the 21st Century 1997) (as quoted by Van der Horst & McDonald, 1997:170). The focus in assessment is shifted from 'notions of "passing" and "failing" to the concept of ongoing growth' (Masters & Forster, 1996:8) (as quoted by van Rensburg, 1998b:84).

As science teachers continually assess the learner progress, some assessments are informal and rely on qualitative judgement about learners' work. Other assessments are formal in the sense that they are included in the curriculum and instruction and provide explicit feedback about learner learning. Thus, effective science Outcomes-Based Assessment should, amongst other things:

- Be embedded in the instructional activities and be consistent with the goals/outcomes of the science program;
- Focused on personal achievement more than group comparisons;
- Provide teachers, learners, and parents with information about (1) the opportunities learners have had to learn science concepts and processes as described in standards, and (2) learner growth and performance relative to developmentally appropriate standards;
- Provide opportunities for learners to identify examples of successful work and progress;
- Strive to avoid bias and provide a fair evaluation of learner learning;
- Incorporate opportunities for learners' reflection on their progress and on feedback from others (Trowbridge et al., 2004:260);
- Be understood by the learner and the broader public;
- Be clearly focused;
- Be based on the pre-set criteria of the Assessment Standards;
- Allow for expanded opportunities for learners;
- Be learner-paced and fair; and
- Be flexible;
- Use a variety of instruments;
- Use a variety of methods (DoE, 2003b:57).

Assessment therefore needs to be developed with a clear sense of curricular purpose and levels of analysis. This includes for whom or for what assessment is playing out its role, and what precisely assessment is thought to be promoting or preventing, crippling or creating, facilitating or inhibiting. Assessment can thus be both facilitative and inhibitive to educational objectives, so appropriate assessment strategies need to be used to attain the assessment aims. The way in which the teaching and learning processes are understood influences the kind of assessment practices that are used (Reddy, 2004a:32).

6.3 Outcomes-Based Assessment approaches

Summative and formative assessments are two broad approaches related to assessment, and they are important decision factors regarding assessment planning and practices (Reddy, 2004:32). Van der Horst and McDonald, (1997:171) identify the three main approaches to assessment as diagnostic, formative and summative, while the DoE (2003b:56) promotes four approaches to assessment, namely baseline, diagnostic, formative and summative.

Pretorius, (1998:83-90); Pahad, (1997:10-11; 41; 45); and Dreyer, (2000:268-271) indicate that assessment should have the following characteristic features. It should be:

- Continuous
- Formative
- Summative
- Diagnostic
- Criterion referenced
- Norm-referenced
- Authentic
- Performance-driven
- Examining
- Practical

Each of these approaches is discussed briefly.

6.3.1 Baseline assessment

Baseline assessment is important at the start of a grade, but can occur at the beginning of any learning cycle. It is used to establish what learners already know and can do. It helps in the planning of activities and in learning programme development. The recording of baseline assessment is usually informal (DoE, 2003b:56).

6.3.2 Diagnostic assessment

Diagnostic assessment is usually done at the beginning of the term, year or new topics to ascertain the starting point for teaching. It examines the learners’ existing knowledge, skills, interests and attitudes, and determines what misconceptions are evident (i.e. strengths and weaknesses). Techniques include observation and testing or any form of assessment. Diagnostic assessment can affect the selection of content for learning, the methods of teaching, and ways of grouping learners (Dreyer, 2000:269). It assists in deciding on support strategies or identifying the need for professional help or remediation. It acts as a checkpoint to help redefine the Learning Programme goals, or to discover what learning has not taken place so as to put intervention strategies in place (DoE, 2003b:56).

6.3.3 Formative assessment

Formative assessment monitors learning progress during instruction (Kotze, 2004:49). It is designed primarily to support the teaching and learning process. It refers to observations that allow one to determine the degree to which learners know or are able to do a given learning task, and that identify the part of the task that the learner does not know or is unable to do (Dreyer, 2000:269). It provides feedback to the learners. Formative assessment is a crucial element of teaching and learning. It monitors and supports the learning process. All stakeholders use this type of assessment to acquire information on progress of learners. Constructive feedback is regarded as the vital component of assessment for formative purposes (DoE, 2003b:56).

6.3.4 Summative assessment

Summative assessment is a form of assessment used to assess the achievement of learners at the end of the instruction in order to document learner performance after instruction has been completed (Kotze, 2004:50). It gives a picture of a learner's competence or progress at any specific moment. It can happen at the end of a single learning activity, a unit, cycle, term, semester, or year of learning. The most important fact about this assessment is that it should be well planned and a variety of assessment instruments and strategies should be used to enable learners to demonstrate competence (DoE, 2003b:56).

6.3.5 Continuous assessment (CASS)

Teachers' assessment of learners' performance must have a great degree of reliability. This means that teachers' judgements of learners' competences should be generalisable across different times, assessment items and markers (Refer to paragraph 5.4-5.5). The judgements made through assessment should show a great degree of validity; that is, they should be made based on the aspects of learning that were assessed (DoE, 2003b:57).

No assessment can be totally valid or reliable by itself, and therefore decisions on learner progress must be based on more than one assessment. This is the principle behind continuous assessment

(CASS). CASS is a strategy that bases decisions about learning on a range of different assessment activities and events that happen at different times through the learning process. It involves assessment activities that are spread throughout the year, using various kinds of assessment instruments and methods such as tests, examinations, projects and assignments. Oral, written and performance assessments are included. The different pieces of evidence that learners produce as part of the continuous assessment process can be included in a portfolio (DoE, 2003b:57).

Continuous assessment acknowledges that we cannot change the instructional process unless we change the assessment process. If learners are assessed in an ongoing way, it means that the whole range of school- and homework can be acknowledged. All the work the learner does will then be given the status and value that has in the past been reserved for examinations and written tests (Puhl, 1997:1-3) (as quoted by Dreyer, 2000:269). CASS encourages integration of assessment into teaching and the development of learners through ongoing feedback.

CASS is both classroom based and school based, and focuses on the ongoing manner in which assessment is integrated into the process of teaching and learning. Teachers get to know their learners through their day-to-day teaching, questioning, observation, and through interacting with the learners and watching them interact with one another (DoE, 2003b:57). Through informal daily assessment and the formal Programme of Assessment CASS should be used to:

- Develop learners' knowledge, skills and values
- Assess learners' strengths and weaknesses
- Provide additional support to learners
- Revisit or revise certain sections of the curriculum, and
- Motivate and encourage learners (DoE, 2005a:1).

6.3.6 Criterion referenced

Even though it does not feature within the NCS as an independent assessment feature, criterion referenced assessment pertains to the specific performance that was demonstrated. It is designed to provide a measure of performance that is interpretable in terms of a clearly defined and delimited domain of learning tasks (e.g. doing eight calculations within 10 minutes without error). It determines the level of performance obtained (Kotze, 2004:50). Criterion referenced testing and norm-referenced testing are often referred to as if they serve the same purposes or share the same characteristics. Criterion referenced assessment is used to find out how much learners know before instruction begins and after it has finished (Dreyer, 2000:269).

6.3.7 Norm referenced

Norm referenced assessment differs from criterion referenced assessment in the sense that in norm referenced assessment learners' achievements are compared with those of other learners or with pass marks or benchmarks to determine how well the learner is doing. This approach does not say much about what the learner has mastered or understood, but seems to focus on how much of the content knowledge the learner knows. It is almost always associated with summative assessment (Reddy, 2004a:34). The purpose of norm referenced assessment is to rank each learner with respect to the achievement of others in broad areas of knowledge. Norm referenced assessment is mainly used to discriminate between high and low achievers (Dreyer, 2000:270).

6.3.8 Authentic assessment

Authentic assessment refers to activities that are meaningful to the learner and represent applications to everyday life. It is assessment that is done for real purposes. The assessment task uses processes appropriate to the discipline and learners value the task (Dixon-Krauss, 1996:143; Hadley, s.a.:16; Clarke, 1996:324) (as quoted by Kotze, 2004:51) (Refer to paragraph 5.3.1 for more information on authentic assessment).

As compared to traditional tests, an authentic assessment instrument that measures problem solving are often thought to be a better reflection of the criterion performances that are of importance in the learners' future professional careers (Segers, 1997:388).

6.3.9 Performance driven assessment

Performance based assessment, according to Dreyer (2000:270), is the direct, systematic observation and rating of learner performance of an educational outcome, often an ongoing observation over a period of time, and typically involving the creation of products. The assessment may be a continuing interaction between teacher and learner and should ideally be part of the learning process. Dreyer (2000:270) indicates that the assessment should be a real-world (i.e. authentic) performance with relevance to the learner and learning community. It is a test of the ability to apply knowledge in a real-life setting (Brualdi, 1998:1) (as quoted by Dreyer, 2000:270).

It is evident that there is a total shift from traditional assessment to the new assessment practices (i.e. the Outcomes-Based Assessment). It has indeed shifted from the notions of "passing" and "failing" to the concept of ongoing growth (Masters & Forster, 1996:80) (as quoted by Dreyer, 2000:270). The emphasis is on the skills that learners have developed, their knowledge and understanding, whereas with the methods above, the emphasis fell on one individual compared with another (Dreyer, 2000:270).

6.4 Outcomes-Based Assessment methods

There are different methods of assessment that may be used to assess learners. The assessment method that one can use is dictated by the purpose of the assessment. Dreyer (2000:271, quoting Sanders & Horn, 1995:1) indicates that there is no single method that can be used to appraise the totality of a learner's school and learning experience, or that can do justice to the diversity of the learners who must be accommodated. It should be clear that the issue here is not whether one method or form of assessment is intrinsically better than another, but to establish a more measured, analytical approach to assessment in education. According to Dreyer (2000:271), we need to resist the tendency to think in simplistic terms of one particular form of assessment as better than another: consideration of form without consideration of purpose is wasted effort. We must develop and propagate a wider understanding of the effect of assessment on teaching and learning, for assessment does not stand outside teaching and learning, but stands in dynamic interaction within it (Dreyer, 2000:271). Dreyer (2000:271) stresses the fact that we need also to foster a system that supports multiple methods of assessment, while at the same time making sure that each one is used appropriately.

Each of these assessment methods is discussed in paragraphs 6.4.1 – 6.4.6 respectively.

6.4.1 Self-assessment

The DoE (2003b:58) indicates that all Learning Outcomes (LOs) and Assessment Standards (ASs) are transparent so that learners will know what is expected of them. Learners can therefore play an important part in "pre-assessing" work by means of self-assessment before the teacher does the final assessment. O'Malley (1997:3) (as quoted by Dreyer, 2000:272) states that "self-assessment is the key to learner empowerment because it gives learner opportunity to reflect on their own progress toward instructional objectives, to determine the learning strategies that are effective for them, and to develop plans for their future learning". With self-assessment, learners are active participants in deciding what and how much to learn and in setting the criteria according to which their learning is evaluated (Dreyer, 2000:272).

6.4.2 Peer assessment

Peer assessment occurs when some or all of the learners evaluate a learner's work (Dreyer, 2000:273). In this assessment, a checklist or rubric is used to help both the learners whose work is being assessed and the learners that are doing the assessment. The sharing of the criteria for assessment empowers learners to evaluate their own and others' performances (DoE, 2003b:58). Learners can also rate the oral and written work of their peers, identifying areas that can be improved, as well as those presented effectively (O'Malley, 1997:4) (as quoted by Dreyer, 2000:273).

According to Dreyer (2000:273) self-assessment and peer assessment are designed to allow learners to take more responsibility for their learning by reflecting on it and by receiving feedback from their peers. The two assessment methods are particularly powerful formative evaluation. Dreyer (2000:271) mentions that the essential difference between the two methods as is that in self-assessment the learner is learning about learning itself by reflecting on his or her own activities. In peer assessment, the learner is learning about learning by reflecting on the activities of another learner. Used sensitively, with more emphasis on learner growth and self-understanding than on arriving at a final mark, self-assessment can contribute to a learner's ability to structure his or her learning. It can increase a learner's ownership of the learning process. One of the main advantages of self- and peer assessment is that learners internalise the standards for learning more readily than they would from teacher assessment alone (Dreyer, 2000:273). Another advantage (Dreyer, 2000:273) concerns time management for teachers, who need only to spot-check learner performance rather than to spend time rating every single product from each learner.

6.4.3 Group assessment

The Critical Outcomes within the National Curriculum Statement require learners to work effectively with others as members of a team, group, organisation and community. The Developmental Outcomes stresses that learners should be able to participate as responsible citizens in the life of local, national and global communities (DoE,2003b:2). Therefore, the ability to work effectively in groups is essential. Assessing group work involves looking for evidence that the group of learners cooperate, assist one another, divide work, and combine individual contributions into single composite assessable product. Group assessment looks at process as well as product (DoE, 2003b:58).

Process assessment refers to a different set of assessment approaches. It aims to determine the quality of the process itself, either the learning process, or more often, the problem-solving process. Not only is the result of a particular process regarded as important, but also the process that underlies that result. Process assessment becomes extremely important when higher-order learning and divergent thinking is the aim. In such cases, the product itself cannot be predicted (du Toit & du Toit, 2004:8).

Product assessment refers to all kinds of assessment that measures what has been learned by looking at the result of the learning activities of the learner. Product assessments are especially suited when lower-order cognitive processing is tested. In general, the outcomes of this kind of processing can be easily measured. Product assessment can be used to establish if and whether or to what extent learners have acquired factual or conceptual knowledge and/or are able to apply algorithms in well structured domains (du Toit & du Toit, 2004:8).

Group assessment involves assessing social skills, time management, resource management and group dynamics, as well as the output of the group (DoE, 2003b:58).

6.4.4 Portfolio

A portfolio (Dreyer, 2000:272) can be defined as a meaningful collection of a learner's work in an attempt to give a fuller picture of what a learner has achieved. A teacher puts a portfolio together for each individual learner, using materials produced by that learner. These materials can include a large variety of products, such as worksheets, pictures, assignments completed, data sheets, written conclusions, experiment reports, maps, stories, plans, and any other written material related to the work completed for a unit or grade (Trowbridge et al. 2004:252-253).

A portfolio must be a purposeful collection of a learner's work that tells the story of the learner's efforts, progress, or achievement in a given area over a period of time. Portfolios can reflect attitudes and values, as well as skills and knowledge. This makes them particularly useful to employers, looking for the "right kind" of applicants for jobs. A well-designed portfolio system can accomplish several important purposes: it can motivate the learner, it can provide explicit examples to parents, teachers, and others of what learners know and are able to do, it allows learners to chart their growth over time and to self-assess their progress, and, it encourages learners to engage in self-reflection (Dreyer, 2000:272). Its primary worth is that they allow learners the opportunity to evaluate their work as well as offer "learners a way to take charge of their learning; it also encourages ownership, pride, and high self-esteem" (Frazier & Paulson, 1992:64) (as quoted by Dreyer, 2000:272). Thus, the Department of Education (DoE, 2005a:5) recommends that each teacher should be in possession of a portfolio. The programme of Assessment should be recorded in the teacher's portfolio of assessment.

The teacher's portfolio should include the following:

- A content page
- The formal Programme of Assessment
- The requirements of each of the assessment tasks
- The tools used for assessment for each tasks, and a recording sheet for each class.

The department also recommend that every learner should maintain a portfolio of the assessment tasks that make up the Programme of Assessment. The following should be enclosed:

- A content page
- All of the assessment tasks that make up the Programme of Assessment for the grade (including tests and examinations)
- The tools used for assessment for each tasks; and
- A record of marks achieved for each of the tasks.

6.4.5 Practical investigations and experiments

This method of assessment provides information on learners' skill and problem-solving abilities through the use of apparatus set-ups, experiments, and open-ended situations that can reveal certain thinking processes. Learners who have become familiar with investigative learning will be able to display their abilities to their best advantage (Trowbridge et al. 2004:253). Practical investigations and experiments should assess learning outcomes with the focus on the practical aspects and the process skills required for scientific inquiry and problem solving. Assessment activities (DoE, 2005a:10) should be designed so that learners are assessed on their use of scientific inquiry skills, like planning, observing and gathering information, comprehending, synthesising, generalising, hypothesising and communicating results and conclusions. It should assess performance at different cognitive levels across all LOs, with greater focus on LO 1(DoE, 2005a; 10).

6.4.6 Examinations and tests

Race (2000:2) (as quoted Dreyer, 2000:272) states that: "Despite growing concern about the validity and fairness of this type of assessment, for all sorts of reasons it will continue to play a large part in the overall assessment picture". According to the National Curriculum Statement's subject assessment guidelines for Physical Science, the programme of assessment in the Further Education and Training band (FET) consists of the tasks undertaken during the school year and end-of-year examination. The marks allocated to assessment tasks completed during the year are 25%, and the end-of-year examination is 75% of the total mark (DoE, 2005a:2). The 75% end-of-year examination in Grade 12 is made up of externally set assessment, which is also marked and moderated externally. Though the Grade 10 and 11 end-of-year examination tasks are set externally, they are marked and controlled internally.

As envisaged by Race (2000:2, as quoted by Dreyer, 2000:272), the traditional “unseen” tests and exams still make up the lion share of assessment in schools and in higher education. Exams can be more cost-effective than many of the alternatives, although this depends on economies of scale when large numbers of learners are examined, and also on how much time and money needs to be spent to ensure appropriate moderation of learners’ performance. Exams are demonstrably fair in that learners all have the same tasks to do in the same way and within the same timescale. Again it is easier to be sure that the work being assessed was done by the candidates, and not by other people (Dreyer, 2000:272).

Some of the disadvantages of the traditional exams include that learners get little or no feedback about the detail of their performance, which is, therefore, wasted as far as feedback is concerned. Badly set exams encourage surface learning, with learners consciously clearing their minds of one subject as they prepare for exams in the next subject (Dreyer, 2000:272). According to Race (2000:2), exams tend to measure how good learners are at answering exam question, rather than how well they have learned (as quoted by Dreyer, 2000:272).

6.5 Moderation of assessment tasks

All Grades 10 and 11 tasks are internally moderated, while all Grade 12 tasks need to be externally moderated. The subject head or head of department for Physical Sciences at the school will generally manage this process (DoE, 2005a:14). It is recommended that the moderation of assessment tasks should take place at three levels.

Level 1: School - The Programme of Assessment should be submitted to the subject head and School Management Team before the start of the academic year for moderation purposes.

- Each task that will be used as part of the Programme of Assessment should be submitted to the subject head for moderation before learners attempt the task.
- The teacher and learner portfolios should be moderated twice a year by head of the subject or his/her delegate.

Level 2: Cluster/district/region - Teacher portfolio and a sample of learner portfolios must be moderated twice during the first three terms.

Level 3: Provincial/national - Teacher portfolios and a sample of learner portfolios must be moderated once a year.

6.6 Conclusion

Total validity and reliability of assessment are the most important aspects that need thorough consideration when setting and marking assessment tasks. To overcome this, the Department of Education (SA) came up with continuous assessment. Continuous assessment (CASS), which is both classroom-based and school-based, focuses on the ongoing integration of assessment into the process of teaching and learning (DoE, 2003b:57).

Magone et al. (1994, as quoted by Segers, 1997:388) use different sources of logical and empirical evidence for judging the validity of this assessment instrument: well-defined task specifications, systematic internal and external reviews of each task, and qualitative analysis of learners' responses. This quantitative analysis focuses on the processes underlying task performance: "Does the analysis of the learners' responses indicate their conceptual understanding and their ability to use basic concepts to solve a problem"? According to Magone et al., (1994) the results support the validity of the instrument. The results suggest that the task requires high-level thinking and reasoning processes (Segers, 1997:388).

The multiple methods of assessment referred to in this chapter (Chapter 6) can provide learners with varied opportunities to communicate what they know and can do, what learning process works effectively for them, and what progress they have made over time. Such opportunities (Dreyer, 2000:279) put learners in a better position to manage their learning and to become self-directed learners. However, teachers need to ensure that learning is not simply assessment-driven or exam driven as it makes up 75% of the total assessment tasks.

For assessment to be effective, the findings by Segers (1997:395) suggest that feedback should by all means involve two dimensions: the breadth and depth of learners' knowledge profile and the extent to which this knowledge is usable (i.e. Assessment Standard). No single assessment technique can satisfy both assessment dimensions without presenting a distorted view of a learner's capabilities (Birenbaum, 1996 as quoted by Segers, 1997:395). Therefore, a variety of assessment tools is preferable to a single tool.

The next chapter (Chapter 7) discusses the Outcomes and Taxonomies of Educational Objectives.

CHAPTER 7

Outcomes and taxonomies of educational objectives

7.1 Introduction

Traditionally, teaching was, and in many instances still is, offered in so-called teacher-centred ways that focus on the transmission of knowledge in fairly rigid ways. Such a transmission approach "forgets" what the learners are expected to accomplish (i.e. the objectives or outcomes). Educational outcomes are one of the pervasive features in recent educational reform (Andrich, 2002:35). Outcomes-Based Education, unlike the traditional approach to science teaching, emphasizes behavioural outcomes/objectives. It is customary to think of objectives or outcomes in terms of three aspects: cognitive, affective and psychomotor. These concepts come from the work of Benjamin Bloom and others, who developed taxonomies of educational objectives (Trowbridge et al., 2004:91). The search for this common language has led to the creation of taxonomies of learning – hierarchical ways of classifying possible learning outcomes to show the progression from simple outcomes to complex outcomes (Killen, 2004:67).

It is useful to have a common language for describing the things that learners need to learn in order to help teachers think about, discuss and clarify the range of outcomes. As outcome statements are developed, it soon becomes obvious that not all outcomes are equal. Some will refer to simple ideas, others to complex ideas; some will require low levels of skill, others large changes. The key to making OBE successful is to systematically and consistently apply the fundamental principles as espoused by Spady (1994) (as quoted by Killen, 2004, 67), namely clarity of focus, designing down, high expectations and expanded opportunity (Refer to paragraph 4.3.3).

It is the main aim of this chapter to articulate a framework that can help to place the movement in a historical context and thereby advance its discourse on National Curriculum Statement (NCS) with emphasis on the cognitive domain.

7.2 Influences of Bloom's Taxonomy on NCS

The taxonomy grew out of the College setting in North America, in particular the University of Chicago, where students enrol in a liberal arts/science program before embarking on professional studies. Bloom, as a College Examiner and then University Examiner, acted on his observation that the intention of education was to develop "….. higher mental processes" (Bloom, 1994:2) (as quoted by Andrich, 2002:40). The motivation for the taxonomy was to develop a common framework for setting improved examinations to assess these. The construction of the taxonomy involved a group of people, who agreed ".. that the framework might best be obtained through a system of classifying the goals of the educational process using educational objectives" (Bloom, 1994:2, as quoted by Andrich, 2002:40).

Learner behaviour is central to the development of the taxonomy. It can also help one gain a perspective on the emphasis given to certain behaviours by a particular set of educational plans. Indeed, the plan was to translate the educational objectives immediately in terms of the behaviours that would provide and manifest the evidence that the objective was achieved (Andrich, 2002:41). Bloom (1994:3) states that: "to overcome the problem of classifying objectives which could not be observed or manipulated as directly as those in the physical or biological science, the group decided that virtually all educational objectives when stated in behavioural form have their counterparts in learner behaviour. These behaviours, then, could be observed and description could be classified" (as quoted by Andrich, 2002:41).

This origin of the taxonomy contributes to its significance in the area of educational assessment. Curriculum developers should find that the taxonomy helps them specify objectives so that it becomes easier to plan learning experiences and prepare evaluation devices (Bloom et al., 1956:2) (as quoted by Andrich, 2002:41 & Trowbridge et al., 2004:90). "In short, teachers and curricular designers should find this a relatively concise model for the analysis of *educational outcomes* in the cognitive area of remembering, thinking, and problem solving" (Bloom et al., 1956:2, as quoted by Andrich, 2002:41).

As OBE forms the foundation for the curriculum in South Africa, it strives to enable all learners to reach their maximum learning potential by setting the Learning Outcomes (LOs) to be achieved by the end of the education process (DoE, 2003b:2). This is in accordance with the original taxonomy of educational objectives.

7.3 The taxonomy as a component analysis of educational objectives

Anderson and Krathwohl (2001:3) relate the lament from a middle school teacher, who, when s/he first heard about the possibility of statewide standards, was intrigued. S/he thought that it might be nice to have a clear idea of what learners were expected to know and be able to do in each subject at each level. But when s/he saw the drafts of the standards, s/he was appalled. There were 85 standards in sixth-grade English language arts. There was more than 100 in sixth-grade Mathematics. And they were so vague. S/he asked herself/himself how these things can possibly help one to teach better and one's learners to learn better. This problem is similar to one of the problems that resulted in the establishment of a Ministerial Review Committee in 2001 in South Africa (refer to paragraph 4.3).

According to Anderson and Krathwohl (2001:4), to deal with the problem of an exceedingly large number of vague objectives, teachers need to organize the objectives in some way. An organizing framework that increases precision and, most importantly, promotes understanding is needed in order to make them more precise and to avoid vagueness. According to Anderson and Krathwohl (2001:4), a framework consists of a set of categories related to a single phenomenon (e.g., minerals, fiction). They can be likened to "bins" into which objects, experiences, and ideas can be placed. Objects, experiences, and ideas that share common characteristics are placed in the same "bin". The criteria that are relevant in the sorting process are determined by a set of organizing principles, principles that are used to differentiate among the categories. Once classified, the characteristics of each category as well as the characteristics of the other categories in the framework help teachers to better understand what is placed in the category (Anderson & Krathwohl, 2001:4).

Anderson and Krathwohl (2001:4) explain taxonomy as a special kind of a framework for the categories that lie along a continuum. The continuum becomes one of the major organizing principles of the framework. The Anderson and Krathwohl (2001:4) taxonomy of educational objective classifies objectives, which in education indicate what we want learners to learn. They are "explicit formulations of the ways in which learners are expected to be challenged by the educative process. A statement of an objective contains a verb and a noun. The verb generally describes the intended cognitive process. The noun generally describes the knowledge learners are expected to acquire or construct" (refer to Table 7.8) (Anderson & Krathwohl, 2001:3 and DoE, 2007:17).

As teaching is always an intentional and reasoned act, objectives are important. Teachers always teach for some purpose, primarily to facilitate learner learning. The intentional aspect of teaching concerns how teachers help learners achieve the teachers' objectives, that is, the learning environments the teachers create and activities and experiences they provide. The learning environments, activities, and experiences should be aligned with, or be consistent with, the selected objectives. The objectives are sometimes referred to as goals, aims, purposes, and guiding outcomes. Despite what they are called, objectives are present in virtually all teaching (Anderson & Krathwohl, 2001:3).

The following paragraphs (7.3.1 – 7.3.5) will present component analysis of educational objectives as taxonomy can be fitted into the framework of a component analysis of educational objectives at different levels of scale.

7.3.1 Level 1. Cognitive, affective and psychomotor domain

At the first level the educational objectives are divided into three basic domains (Andrich, 2002:41), namely cognitive, affective and psychomotor. Briefly, the cognitive domain refers to the intellectual/mental process, the affective domain to the emotional and attitudinal components, and psychomotor domain to physical skills of educational objectives (Andrich, 2002:41; Killen, 2004:69 & Trowbridge et al., 2004:91). Although these three areas of educational objectives are all articulated and the development of taxonomies appear in all three areas, the one first developed (Andrich, 2002:41) and generally most emphasized has been that of the cognitive domain (Trowbridge et al., 2004:91 & Andrich, 2002:41).

These distinctions have proved useful, even though most educational objectives involve some combination of all three domains. In general one cannot have one domain involved without at least some components of the others. Indeed, in first resolving the educational objectives into these three domains, the relationship between them can be brought out more explicitly than if they were not distinguished (Andrich, 2002:42).

7.3.2 Level 2. Hierarchy of levels of cognitive domain

Bloom’s taxonomy organizes cognitive processes into six levels of increasing complexity:

1 **Knowledge:** This represents the lowest level of science outcomes. The definition of knowledge for this level is: remembering previously learned scientific material. The requirement is simply recall (i.e. bring to mind) of appropriate information. The range of information may vary from simple facts to complex theories, but all that has to be done is to recall the information (Trowbridge et al., 2004:91). Outcomes at this level will typically use verbs such as name, list, define, label, select, state, write, describe, identify and recall (Killen, 2004:69).

2 **Comprehension**: This involves making meaning of things rather than just recalling them. It is the first level of understanding and demonstrating scientific information. It is the ability to apprehend, grasp, and understand the meaning of scientific material (Trowbridge et al. 2004:91). Outcomes written at this level will typically use verbs such as match, describe, convert, illustrate, distinguish, interpret, rewrite, discuss, give examples, and summarise (Killen, 2004:69).

3 **Application**: Application is the ability to use abstract information and ideas in concrete situations, such as solving problems that have single or best answers (Killen, 2004:69). At this level students may apply scientific concepts, methods, laws, or theories to actual

concrete problems (Trowbridge et al., 2004:91). Outcomes written at this level will typically use verbs such as calculate, demonstrate, construct, compute, solve, relate, solve, use and apply (Killen, 2004:70).

4 **Analysis**: This is the ability to examine information systematically to identify the parts so that the relative hierarchy of the ideas is made clear and/or the relations between the ideas are made explicit. Outcomes written at this level will typically use verbs such as analyse, differentiate, categorise, classify, relate, illustrate, outline, compare, contrast, discriminate, explain and hypothesise (Killen, 2004:70).

5 **Synthesis**: This requires the formulation of a new understanding of scientific systems. If analysis stresses the parts, synthesis stresses the whole. Outcomes written at this level will typically use verbs such as plan, adapt, combine, create, compile, compose, construct, design, develop, formulate and organize (Killen, 2004:70 & Trowbridge et al., 2004:91).

6 **Evaluation**: Evaluation is the highest level of learning in the hierarchy. This involves making judgments about the quality of things based on internal evidence and/or clearly defined external criteria. Outcomes written at this level will typically use verbs such as assess, judge, choose, criticize, rate, argue, justify, evaluate, decide, recommend and conclude (Killen, 2004:70 & Trowbridge et al., 2004:91).

It is evident that this classification is hierarchical. The intention is that each level should incorporate the level before it. In this way it is analogous to the tree structure (Figure 7.3.1) (Andrich, 2002:42).

Despite its simplicity, Bloom's taxonomy has had many critics, as well as supporters. Many of these criticisms stem from the fact that the taxonomy was developed at a time when the primary learning theory was behaviourism, so it does not take into account some of the recent theories about knowledge and about how people learn (Killen, 2004:87).

It was then updated to reflect new ways of thinking about cognition and learning. In contrast with the single dimension of the original taxonomy, the revised framework is two-dimensional. The two dimensions are cognitive processes and knowledge (refer to Table 7.1) (Anderson & Krathwohl, 2001:5).

7.3.3 Level 3. The level of analysis

Each level of the six levels explained above can further be divided into its components. Andrich (2002:43) uses a tree structure (Table 7.2) to show how the Taxonomy of Educational Objectives can be analysed into components. This division is also eminent in the Anderson-Krathwohl taxonomy, where the hierarchy of cognitive processes involved in learning and in demonstrations of learning, by Bloom, is still retained in the revised taxonomy, but develops and extends the original taxonomy in several useful ways. The first difference comes from recognising that 'just as there are different cognitive processes, there are different components of knowledge; comprehension; application; analysis; synthesis; and evaluation' (Anderson & Krathwohl, 2001:232 and Killen, 2004:72).

Using level of *analysis* to reiterate that one realises that it comprises of the following components:

- Analysis of elements
- Analysis of relationships
- Analysis of organisational principles (Andrich, 2002:42).

This goes further to the sub-components.

7.3.4 Level 4. The subcomponents of analysis of organisational principles

Again (Andrich, 2002:42), taking one of these by way of an illustration, the sub-components of *analysis of organisational principle*s are shown below:

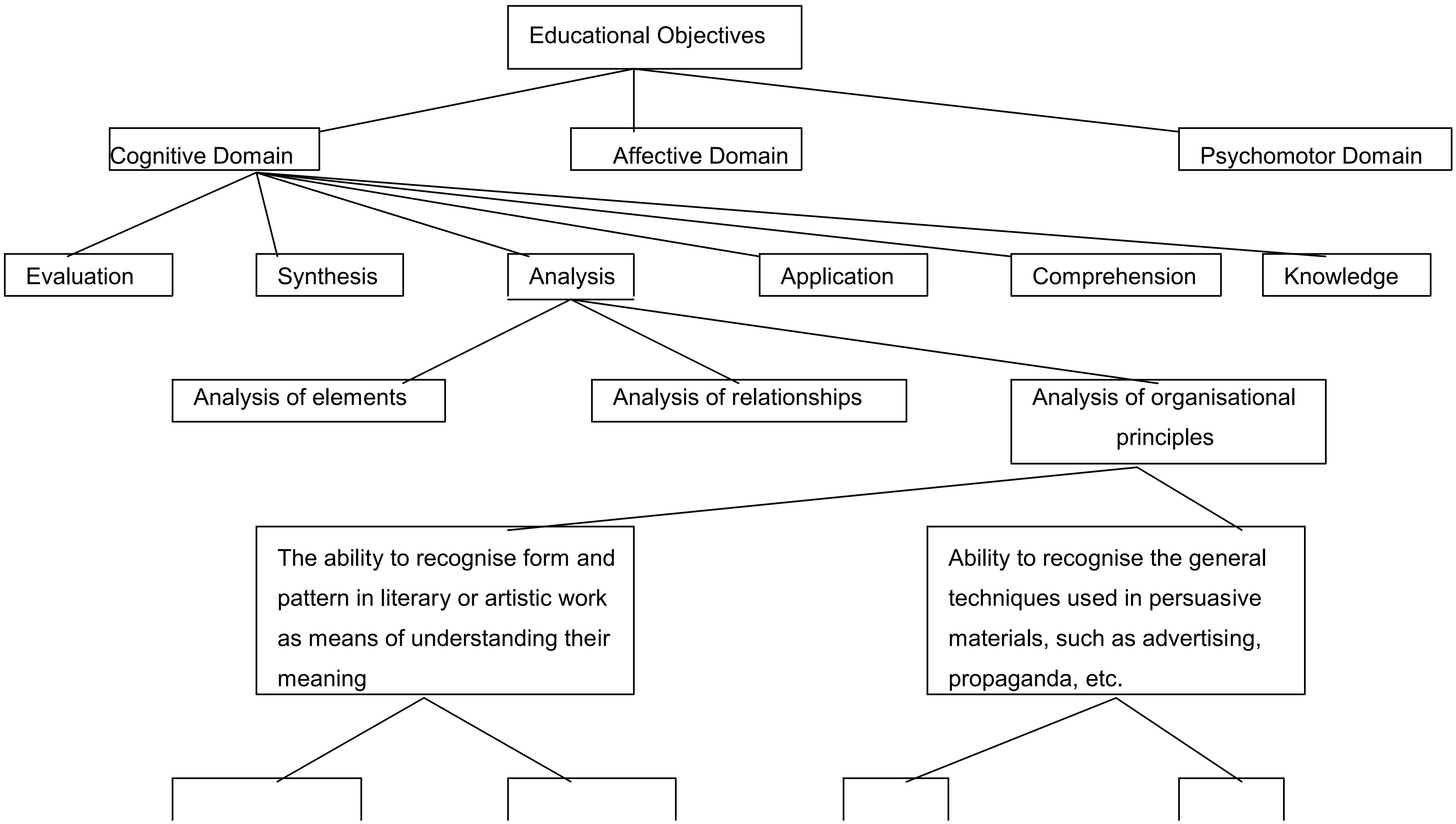
- The ability to recognise form and pattern in literary or artistic works as means of understanding their meaning.
- Ability to recognise the general techniques used in persuasive materials, such as advertising, propaganda, etc.

It is important to note that at Level 4, when compared to Level 1, the content has reached a relatively concrete and observable stage (Andrich, 2002:42).

7.3.5 Level 5. Specific verbs or behaviour

Finally, there are terms that become tangible in defining the evidence that will illustrate that the objective has been achieved. One of the key features of the use of the taxonomy has been the development of a set of verbs, action words that operationalise its different levels in terms of behaviours (Andrich, 2002:43). The component analysis of the Taxonomy illustrated above is summarised by figure 7.1.

Figure 7.1 The component analysis of the taxonomy of educational objectives



7.4. The Anderson-Krathwohl Taxonomy

The Bloom's Taxonomy has been updated (Anderson & Krathwohl, 2001). According to Andrich (2002:36), the need for an update and the results of the process can be compared to the perceived need to develop Outcomes-Based Education and the results of that development.

The Anderson-Krathwohl taxonomy for learning, teaching and assessing provides a very useful way of focusing on four questions that are fundamental to teaching in general (Anderson & Krathwohl, 2001:232 and Killen, 2004:71), and even more so to Outcomes-Based Education:

1. What is important for learners to learn in light of the limited school and classroom time available? Anderson and Krathwohl (2001:232) find this to be the learning question.
2. How can instructions be planned and delivered so that all learners achieve high levels of learning? (This is regarded as the assessment question)
3. What assessment instruments and procedures will provide accurate information about how well learners are learning?
4. How can teachers ensure that outcomes, instruction and assessment are consistent with one another? (The alignment question) (Anderson & Krathwohl, 2001:232).

The emphasis on state-level standards is intended to provide at least a partial answer to the learning question. However, as the frustration of a middle school teacher (paragraph 7.3) indicates, simply having standards does not necessarily provide a sound, defensive answer. The answer to learning lies in a large part on the way in which time is allocated in the classroom and the emphasis conveyed to the learners about what is really important. Looking through the lens of the Taxonomy Table (Table 7.1), teachers can see more clearly the array of possible objectives, as well as the relationship between them. Analysing all parts of the curriculum in terms of the Taxonomy Table provides for complete understanding of the curriculum (Anderson & Krathwohl, 2001:7).

The Taxonomy Table (Table 7.1) may suggest the range and types of cognitive objectives to consider. To effectively respond to such a challenge, it should firstly be clear that different types of objectives require different instructional approaches, that is, different learning activities, different curricular materials, and different teacher and learner roles. Secondly, similar types of objectives – regardless of differences in the topic or subject matter – may require similar instructional approaches. Given particular kinds of instructional goals, for example, list a variety of instructional characteristics that facilitate their achievement (Anderson & Krathwohl, 2001:8).

Classifying a particular objective within the Anderson and Krathowhl (2001:8) framework helps teachers to systematically plan a way of effectively facilitating learners' learning of that objective (Anderson & Krathwohl, 2001:6).

The two points made in the preceding paragraphs apply to assessment as well. Different types of objectives require different approaches to assessment and similar types of objectives likely involve a similar approach to assessment. The degree of alignment among the objectives, instruction, and assessment is very important. The degree is determined by comparing objectives with assessment, objectives with instruction, and instruction with assessment. Whoever designed the curriculum, the taxonomy should help teachers make sense of the curriculum, plan instruction, and design assessment that is aligned with the objectives inherent in the curriculum, and ultimately improve their teaching quality (Anderson & Krathwohl, 2001:11).

Table 7.1 The Taxonomy Table (Anderson & Krathwohl, 2001)

THE KNOWLEDGE DIMESION	**THE COGNITIVE PROCESS DIMENSION**					
	1. Remember	**2. Understand**	**3. Apply**	**4. Analyze**	**5. Evaluate**	**6. Create**
A: Factual knowledge						
B: Conceptual knowledge						
C: Procedural knowledge						
D: Meta-cognitive knowledge						

7.4.1 The cognitive process dimension

The cognitive process dimension of Anderson-Krathwohl taxonomy differs from Bloom's taxonomy in three ways (Killen, 2004:72):

1 First, the labels on each section are now verbs (rather than nouns) to emphasise that the cognitive processes are 'thinking actions' (Table 7.2).

2 Second, the old notion of 'synthesis' has been replaced with 'create', and its position at the top of the taxonomy emphasises that it is the most complex of the

cognitive processes (Table 7.2).

3 Lastly, the lowest level of cognitive process is referred to as 'remember', and the 'knowledge' category that was the first level of Bloom's taxonomy is now used as a separate dimension (refer to Table 7.2) (Killen, 2004:72).

Table 7.2. Six levels of cognitive processing (Anderson & Krathwohl, 2001).

Cognitive process	What learners are required to do	Example of action verbs
Remember	Retrieve relevant knowledge from long-term memory	Recognise, recall, define, describe, identify, list, match, reproduce, select, state
Understand	Construct meaning from information and concepts	Paraphrase, interpret, give example, classify, summarise, infer, compare, discuss, explain
Apply	Carry out a procedure or use a technique in a given situation – this might involve routinely applying procedures or determining which procedure to use in a particular situation	Change, demonstrate, predict, relate, show how, solve, determine
Analyse	Breaking information into parts and determine how the parts relate to one another and how they relate to an overall purpose or structure	Analyse, compare, contrast, organise, distinguish, examine, illustrate, point out, relate, explain, differentiate, organise, attribute
Evaluate	Make judgements based on criteria and standards	Comment on, check, criticise, judge, critique, discriminate, justify, interpret, support
Create	Put elements together to form a coherent of functional whole, or recognise elements into a new pattern	Combine, design, plan rearrange, reconstruct, rewrite, generate, produce

In a nutshell, the cognitive process dimension (i.e., Table 7.2 and the column of table 7.1) contains six categories: Remember, Understand, Apply, Analyze, Evaluate, and Create. The continuum underlying the cognitive process dimension is assumed to be cognitively complex. Understanding is believed to be cognitively more complex than Remember, Apply is believed to be cognitively more complex than Understand, and so on (Anderson & Krathwohl, 2001:5).

7.4.2 The knowledge process dimension

The knowledge dimension (i.e., Table 7.3 and the rows of table 7.1) contains four categories: Factual, Conceptual, Procedural, and Meta-cognitive. These categories are assumed to lie along a continuum from concrete (Factual) to abstract (Meta-cognitive). The Conceptual and Procedural categories overlap in terms of abstractness, with some procedural knowledge being more concrete than the most abstract conceptual knowledge (Anderson & Krathwohl, 2001:5).

Table 7.3 The knowledge dimension

Knowledge type	Subtype	Example
Factual knowledge	Knowledge of terminology	Symbol of chemical elements; names of parts of a machine
	Knowledge of specific details or facts	Sequence of elements in periodic table; reliable sources of information
Conceptual knowledge	Knowledge of classifications and categories	Types of African music, forms of business ownership
	Knowledge of principles and generalisations	Newton's laws of motion; Pythagoras' theorem
	Knowledge of theories, models and structure	Theory of evolution; information-processing model of cognition
Procedural knowledge	Knowledge of subject-specific skills and algorithms	Skills in drawing a house plan; algorithm for multiplying fractions
	Knowledge of subject specific techniques and methods	Interviewing technique; scientific method of inquiry
	Knowledge of criteria for determining when to use particular procedures	Criteria to determine when to use the 'guess and check' procedure for problem solving; criteria to judge the feasibility of using co-operative learning as a teaching strategy

Meta-cognitive knowledge	Strategic knowledge	Knowledge of flowcharting as a means of showing relationship among elements of a process
	Knowledge about cognitive tasks	Knowledge of the cognitive demands of particular tasks; knowledge of the ways in which understanding is typically tested by educators
	Self-knowledge	Awareness of one's own knowledge level; knowledge of one's personal strengths and weaknesses in learning tasks

7.5 Applying the Anderson-Krathowhl taxonomy

Killen (2004:73) came up with the steps that need to be applied and followed in using the taxonomy grit to align outcomes, instructional procedures and assessment for a module, unit of work or lesson. According to Killen (2004:73):

1. Teachers need to map out each outcome onto the taxonomy grid by answering two questions: 'What type of cognitive process does the outcome require?' and 'What type of knowledge will learners be dealing with when demonstrating the outcome?'
2. It is very important for teachers to select instructional procedures that will enable learners to achieve the outcome.
3. An appropriate assessment procedure should be selected.

According to Killen (2004:73), the above-mentioned three-step process will determine:

1 Whether or not the outcome is appropriate;

2 Whether or not the teaching strategy selected can possibly enable learners to achieve the outcome; and

3 Whether or not the assessment procedure will provide evidence from which valid inferences can be drawn about learners' achievement of the outcome.

The main advantages of the Anderson-Krathwohl taxonomy are that it helps teachers to decide exactly what it is that they want learners to learn (Killen, 2004:73). On the other hand, one limitation of this taxonomy is that it does not describe the quality of learner learning in each cell in the taxonomy. For example, if the outcome was ‘learners will be able to explain the theory of evolution’, we could map this into the ‘understand conceptual knowledge’ cell of taxonomy grid. We could assess the learners’ understanding by asking them to, for example, ‘briefly explain the theory of evolution’. However, we would still be left with the problem of describing the differences in quality of answers from different learners. Some learners will be able to give better explanations than others. Some of the differences will be due to the developmental stage of the learners (Biggs & Collins, 1991) (as quoted by Killen, 2004:76) and some will be due to other factors. To solve this problem (Killen, 2004:76), clear assessment criteria and performance standards must be developed. This issue lead to the field of standards-referenced assessment (refer to paragraph 5.6).

7.6 The SOLO Taxonomy

SOLO is an acronym for Structure of the Observed Learning Outcome. The SOLO taxonomy provides “a general framework for systematic quality [of learning]” (Collins & Biggs 1986:1) (as quoted by Killen, 2004:78) where quality of learning is indicated by the way learners structure their oral or written responses to open-ended questions (Killen, 2002:78). It provides a framework for giving specific feedback to learners.

When defining learning outcomes, declarative knowledge should be stipulated (Tucker, 2004:6). Thus, there should be a clear distinction between knowledge that can be orally or verbally stated or declared as a result of learning, and knowledge that has been acquired that has led the learner to change their view of the world or to behave differently as a result of understanding the knowledge learnt. The SOLO Taxonomy (Biggs & Collin, 1998) (as quoted by Killen, 2004:80), Blooms Taxonomy of Educational Objectives (Bloom, 1956) and the National Curriculum Statement (Subject assessment guidelines) (DoE, 2007:17) give a hierarchy of verbs that can be useful in generating learning objectives of increasing abstractness and complexity (Andrich, 2002:44 and Tucker, 2004:6). In order to produce learning outcomes of sufficient complexity to reflect higher education, learning experiences should include non-observable phenomena and/or abstract concepts (Levels four to six of the SOLO taxonomy) (Tucker, 2004:6).

It is important to realise that the SOLO taxonomy is used to describe a learner’s current state of understanding of some particular content or process, it should not be used to “label” learners (as high or low achievers). Once a learner’s level of understanding is identified, it can be improved through instruction and/or experience. If teachers want learners to be able to operate at a higher level, they have to formulate appropriate outcomes, teach in a way that will help learners to achieve a higher level of understanding, and assess that understanding in an appropriate way.

This notion of capacity for continual improvement is consistent with one of the basic tenets of OBE – all learners can succeed if they are given appropriate opportunities and time to learn (Killen, 2004:80).

7.7 From the Taxonomy to the Outcomes Statements

The Taxonomy has become virtually known, and the Outcomes-Based Education movement, as we shall witness, has many of its characteristics and indeed appears to have drawn on the taxonomy. Still, there should be some reason why the Outcomes-Based Education movement occurred (Andrich, 2002:44). Interesting, also, articulations of Outcomes-Based Education seem not to make any connections to the development of the taxonomy. Andrich (2002:44) indicates some of the structural features of the taxonomy that did not fill the whole void referred to by Bloom, and these seem to be addressed by the Outcomes-Based Education movement (refer to paragraph 7.5).

A distinctive feature of the taxonomy is that it is not referenced to any subject or content matter – it is entirely about cognitive process (Andrich, 2002:45). It does not take into account some of the recent theories about knowledge and about how people learn (Killen, 2002:87). This generality has contributed successfully to many educators in all subject areas and all levels of education thinking beyond the level of knowledge in their curriculum development, teaching, and assessment. However, the very strength of this generality means that it needs to be re-contextualised in every application at least at two levels. First, curriculum developers and examiners (ranging from classroom teachers to system level educators) need inevitably to consider a subject area discipline. Second, the same observable behaviour, so strongly stressed in the development of the taxonomy and NCS, may stand for very different levels of thinking in different contexts (Andrich, 2002:45).

It should be noted that the levels of the taxonomy form a series of cycles where the same observed behaviour in some aspect of learning might imply evaluation or synthesis, and then as the learner becomes more experienced and as learning progresses, drop to lower levels of analysis or application, and eventually become comprehension or knowledge (Andrich, 2002:45). This characterisation of the taxonomy is not a criticism, but it does mean that to apply the Taxonomy in the different subject areas and at different levels, one almost has to begin from the same starting point every time. Outcomes-Based Education seems to address this weakness.

7.8 Outcomes in NCS

An education programme is Outcomes-Based if it describes student outcomes "… quite explicitly in terms of the actual learning learner should exhibit as a result of planned learning experiences in school and developing accountability mechanisms which directly reflect learner performance on those outcomes" (Willis & Kissane, 1997:5). Willis and Kissane (1997:7) go on to summarise three arguments for NCS: "Some argue that it enhances what is actually taught to a learner, others regard it as a means of ensuring that all learners have access and succeed with high quality outcomes, still others see it as improving accountability and the distribution of responsibilities within a school system". In addition (Andrich, 2002:46), to many the case for OBE is a combination of all three arguments. Like the Bloom's Taxonomy, OBE is meant to have multiple purposes. The case of the Learning Outcomes Statement in South Africa fits well within these arguments.

The structure of outcomes in South Africa is high quality, culminating demonstrations of significant learning in context (Spady, 1994:1) (as quoted by Killen, 2004:68). OBE leads to the specification of explicit learner outcome statement (LOs), and inevitably has implications for educational assessment (Andrich, 2002:35). Analogous to Anderson-Krathwohl's focusing questions (paragraph 7.4), teachers need to consider the following points when developing outcome statements:

- What learning are learners required to demonstrate at the end of their learning experience (lesson, semester, year, and compulsory years of schooling, and so on)? This will be the culminating demonstration.
- What could learners be asked to do so that they have an appropriate opportunity to demonstrate their learning?
- Why is this learning important? What makes this learning significant?
- In what ways might learners' performance of this outcome vary? How will teachers distinguish between high quality learning and low learning?

If these questions are answered by writing clear outcomes statements, performance indicators and assessment criteria, then learners will know what learning they are required to demonstrate and how that learning will be judged (Killen, 2004:68).

The outcomes or objectives have two common features, i.e., a verb that describes the action (e.g. collect, analyses, measure, etc.) and a noun or phrase that describes how/where/on what the action will be performed. The main task in writing an outcome is to decide which verb will best describe the learning action and what information is needed to adequately describe the object of that action. If the outcome is clear, it will then be possible to consider the criteria according to which learners' performance will be judged, including the context within which the outcome is to be demonstrated and the standards of performance that are expected of learners. All these things must be clear so that teaching and assessment strategies can be aligned with the outcome (Killen, 2004:69).

The distinctive feature of the OBE is that it starts with the overarching outcomes referred to as the critical outcomes that are comprehensive and deal with the full program of study. This leads to the development outcomes that subsequently lead to the learning outcomes. Further important general matters that link the subsequent components are assessment and development. The length and the breadth of knowledge gained are assessed based on the assessment standards.

From the above short summary of the taxonomy and OBE, the following similarities are noted:

Multiple purpose – although the taxonomy originates from a concern with assessing the goals of learning that go beyond the recall of knowledge, it was expected that it would also be helpful to teachers in planning instruction and the curriculum developers (Bloom, et al., 1956:2-3) (as quoted by Andrich, 2002:50). Likewise, the articulation of outcomes has multiple functions and purposes, in this case beginning with the curriculum, but with serious implications for assessment.

Inclusivity in education – one of the explicit argument arguments for OBE is that by articulating the outcomes to be achieved all learners should have greater opportunity to achieve them (refer to paragraph 4.5.7). Though not as explicit in the taxonomy itself, a great deal of Bloom's work argues that all students should be helped to achieve what relatively few had learned at the time he was writing.

Independence of learning theories – although articulating outcomes and conducting studies in how to achieve them do imply the applications of learning theories, neither the taxonomy nor Outcomes-Based Education make explicit demands or assumptions on only one particular learning theory (Andrich, 2002:50).

Focus on outcomes rather than inputs – Andrich (2002:50) realises that a learner-centred approach and the focus on what should be achieved by all learners, highlights that the emphasis is on outcomes rather than on inputs. This, according to Andrich (2002:50), should not mean that the inputs are not important; but that the inputs are means to achieving the outcomes, and that different learners might reach the outcomes along different routes and with different resources.

The component analysis – A significant feature of the component analysis in both the taxonomy and OBE is that each progressively leads to observable behaviours that count as evidence towards an outcome being achieved (Andrich, 2002:51). In the South African context, the LOs should, by design, lead to the achievement of the COs and DOs (DoE, 2003b:7).

Progress through the hierarchy – Both feature a hierarchy through which the learners are expected to progress. The progression through the hierarchy is more explicitly explained in paragraph 4.5.6 under the heading articulation and portability.

A logical component analysis – the component analysis of both the taxonomy and the OBE involve surface content analysis. Andrich (2002:41) finds that this might be contrasted with component analyses that focus on psychological difficulties in learning concepts. For example, in the NCS of South Africa, learning fields serve as a home for cognate subjects that are not necessarily Learning Fields or 'knowledge' fields, but are rather linked to occupational categories (DoE, 2003b:6).

Teacher role – in both the taxonomy and in the OBE there is a great deal of commentary on the expected role of the teacher, which includes designing the teaching and learning environment to insure that the outcomes are achieved (Andrich, 2002:51).

The paragraphs above indicate that the process of articulating learner outcomes statements within the OBE has the Taxonomy of Educational Objectives as its forerunner. The key similarity between the two is their hierarchical structure, which can be seen as a component analysis of educational outcomes at successively finer levels of scale to the point where these are observable. The most significant difference is that the taxonomy is entirely independent from the content, while the learner outcomes statements are set into content learning areas. OBE can benefit from the experience within the taxonomy, especially with the concern for fragmentation of learning into series of independent and unrelated minute tasks (Andrich, 2002:57).

7.9 Taxonomy and OBA

The NCS requires that the teachers' assessment of learners' performance must have a great degree of reliability. This means that teachers' judgements of learners' competences should be generalisable across different times, assessment items and markers. The judgements made based on assessment should also show a great degree of validity; that is, they should be made on the aspects of learning that were assessed (DoE, 2003b:57).

Paragraph 7.4 indicates that different types of objectives require different approaches to assessment and similar types of objectives likely involve similar approaches to assessment. The degree of alignment among the objectives, instruction, and assessment is very important. The degree is determined by comparing objectives with assessment, objectives with instruction, and instruction with assessment. This means that when stating the objectives/outcomes, the words one uses must describe what one intends. The objective that can be inferred from one's instructional activities must be consistent with one's statement of the objective. When both the objectives and instructional activities are translated into the taxonomy framework, they should point to the same types of knowledge and cognitive processes. Thus, inferring objectives from instructional activities and relating them to the intended objective are the means of ensuring that the instructional activities are "on target" (Anderson & Krathwohl, 2001:96).

For valid assessment, the assessment should align with the stated objectives. This means that the assessment used by the teacher should provide him/her with the information about how well the learners achieved (or are achieving) the objectives. Inference about objectives based on assessments can come from the actual assessment tasks or the criteria used to score or evaluate learners' performance on the assessment tasks. The most important question here is whether inferences based on the assessments leads back to the stated objectives (Anderson & Krathwohl, 2001:96).

In order for teachers to come up with a valid assessment task in Physical Sciences, the Department of Education came up with an Assessment Taxonomy Table that provides a possible hierarchy of cognitive levels similar to that of Bloom's. The table can be used to ensure tasks include opportunities for learners to achieve at various levels and tools for assessing the learners at various levels (Refer to Table 7.9 below) (DoE, 2007:17). Action verbs are also provided for use when questions associated with the cognitive levels in the first column are formulated.

7.10 Physical Sciences and NCS

Historically, a subject has been defined as a specific body of academic knowledge. This understanding of a subject laid emphasis on knowledge at the expense of skills, values and attitudes. Subjects were viewed by some as static and unchanging, with rigid boundaries. Very often, subjects mainly emphasised Western contributions to knowledge. In an Outcomes-Based curriculum, subject boundaries are blurred. Knowledge integrates theory, skills and values. Subjects are viewed as dynamic, always responding to new diverse knowledge, including knowledge that traditionally has been excluded from the formal curriculum (DoE, 2003(a):7).

A subject in an Outcomes-Based curriculum is broadly defined by Learning Outcomes, and not only by its body of content. In the South African context, the Learning Outcomes should by design lead to the achievement of the Critical and Developmental Outcomes in a hierarchical pattern as explained above (paragraph 7.3 and 7.7). LOs are defined in a broad terms and are flexible, making allowances for the inclusion of local input (DoE, 2003b:6).

According to NCS, the subject Physical Sciences focuses on investigating physical and chemical phenomena through scientific inquiry. By applying scientific models, theories and laws, it seeks to explain and predict events in our physical environment. This subject also deals with society's desire to understand how the physical environment works, how to benefit from it and how to care for it (DoE, 2003a:9).

Due to its influence on scientific and technological development, which underpins our country's economic growth and the social well-being of the community, it plays an increasingly important role. The knowledge, skills and values learned in the Physical Sciences should make an impact on the lives of individuals. The application of Physical Sciences knowledge has a profound impact on world-wide issues and events – economic, environmental, ethical, political, social and technological. It fosters an ethical and responsible attitude towards learning, constructing and applying Physical Sciences, and accommodates reflection and debate on its findings, and theories (DoE, 2003a:9).

The purpose of the subject Physical Sciences is to play an increasingly important role in the lives of all South Africans due to its influence on scientific and technological development, which underpins the country's economic growth and the social well-being of the country. Due to its impact in the life of individuals, time allocated to teaching and assessment of Physical Sciences is 38 weeks (DoE, 2005b:8). The study of Physical Sciences as espoused by the National Curriculum Statement is to correct some historical limitations by contributing towards the holistic development of learners in the following ways:

1 Giving learners the ability to work in scientific ways or to apply scientific principles that have proved effective in understanding and dealing with the natural and physical world in which they live;
2 Stimulate their curiosity, deepening their interest in the natural and physical world in which they live, and guiding them to reflect on the universe;
3 Developing insights and respect for different scientific perspectives and a sensitivity to

cultural beliefs, prejudices and practices in society;

4 Developing useful attitudes that will prepare learners for various situations in life, such as self-employment and entrepreneurial venture; and
5 Enhancing understanding that the technological applications of the Physical Sciences should be used responsibly towards social, human, environmental and economic development both in South Africa and globally.

The subject Physical Sciences in the Further Education and Training band builds on the foundation laid by the Natural Sciences Learning Area in the General Education and Training band, thus ensuring progression (paragraph 4.5.5). The credibility and quality of Physical Sciences curriculum is evident in that its focus areas (matter and materials, systems; change; mechanics; waves; sound and light; electricity and magnetism) are internationally recognised as relevant areas for the learning, teaching and assessment of Physical Sciences (DoE, 2005b:10). Learners in the Physical Sciences are, in addition, expected to develop the following competencies also referred to as the Learning Outcomes (LOs):

1 Scientific inquiry and problem-solving skills
2 Construction and application of Physical Sciences knowledge; and
3 Understanding of interrelationship of Physical Sciences, technology, environment and society, and of different attitudes and values.

The National Curriculum Statement Grade 10-12 (General) lays the foundation for the achievement of the goals of nation building by stipulating Learning Outcomes (i.e. Critical Outcomes, Table 4.1 and Developmental Outcomes, Table 4.2) and assessment standards and by spelling out the key principles and values underpinning the Constitution of the Republic of South Africa (Act 108 of 1996) (DoE, 2003(a):2).

The seven Critical Outcomes and the five Developmental Outcomes that are derived from the Constitution of the country need to be reflected in the teaching approaches and methodologies that Physical Sciences teacher’s use. Both teachers and learners should be aware of and focus on these COs and DOs, which will be addressed through Physical Sciences. The relationship between the COs and COs and Physical Sciences Learning Outcomes is shown in the next table (Table 7.4).

Table 7.4: The Relationship amongst COs; DOs and LOs.

Physical Sciences LOs	Critical Outcomes	Developmental Outcomes
LO 1	CO 1; 2; 3; 4; 5.	DO 1
LO 2	CO 4; 5.	DO 1;4
LO 3	CO 1; 3; 4; 6; 7.	DO 2;3

7.11 How is Physical Sciences Assessed in the NCS

The Physical Sciences focuses on investigating physical and chemical phenomena through scientific inquiry. By applying scientific models, theories and laws, it seeks to explain and predict events in our physical environment. In order to harness this, the assessment tasks should focus on the three Learning Outcomes in an integrated manner. The focus of assessment in the NCS should be formative. This means that daily assessment should be used to give feedback to learners as to their strengths and weaknesses and help develop a strategy to improve their learning (DoE, 2005a:7).

The content contained in the LOs and ASs of Physical Sciences NCS was (by the time of this research) divided into core and optional content. The core content to be examined by means of two papers with the anticipation that the content identified as optional will with time become compulsory (DoE, 2005a:7).

7.11.1 How to assess Physical Sciences

According to the NCS (DoE, 2005b:11) planning a lesson means identification of the core knowledge areas as appropriate content for the achievement of LOs. After identification of the LOs and Assessment Standards (ASs) that have to be addressed, the content and context that create multiple opportunities for learners to achieve LOs must be selected (DoE, 2005b:11). Identification of the core knowledge leads the teacher to integrate different LOs and select appropriate ASs that will enable learners to demonstrate achievement of the LOs. It should be noted that there is no one way of integrating these ASs, they can be clustered in multiple ways, depending on the demands of the particular learning programme. The selected ASs will guide the teacher to identify the concepts, skills, values and attitudes that need to be addressed in the Lesson Plans (DoE, 2005b:11). The steps that are followed in achieving the outcomes are analogous to the Anderson-Krathwohl taxonomy (paragraph 7.4 and 7.5). The main advantage of the Anderson-Krathwohl taxonomy is that it helps teachers to decide exactly what it is that they want learners to learn. Physical Sciences Assessment Taxonomy is a usable tool for assessing the learners.

Assessment Standards of Physical Sciences give guidance of the level and depth of the content to be used in achieving the LOs of the subject. The Subject Assessment Guideline has been developed by the Department of Education in order to help teachers implement the OBE-assessment in FET. The purpose of this document is to provide guidelines for assessment in the NCS Grades 10 – 12 (General). To avoid isolating assessment from teaching, the guideline indicates that it should be read in conjunction with relevant department document, e.g., The National Senior Certificate: A Qualification at Level 4 on the NQF and relevant Subject Statements (DoE, 2005a).

Paragraphs 6.4 and 6.5 briefly explained the assessment of Physical Sciences in the NCS.

7.11.2 Programme of Assessment in Grades 10 – 11

Programme of assessment is explicitly explained in paragraph 6.4. The table that follows, (i.e. Table 7.5) only illustrates the suggested Programme of Assessment in Grades 10 and 11.

Table 7.5 Programme of Assessment (Grade 10 – 11) (DoE, 2005a:9)

PROGRAMME OF ASSESSMENT			
ASSESSMENT TASKS (25%)			**End of year assessment (75%)**
TERM 1	TERM 2	TERM 3	TERM 4
Practical investigation	Practical investigation	Research project	Final Examination
Control test	Mid-year examination	Control test	

The assessment tasks that are used in the Physical Sciences are;

→ **Control test and examinations**: control tests and examinations are written under controlled conditions within a specified period of time. Questions in tests and exams assess performance at different cognitive levels across all the LOs, with great focus on LO 2.

→ **Practical investigations and experiments**: assess all the LOs with the focus on the practical aspects and process skills required for scientific inquiry and problem solving skills (refer to paragraph 6.4.5).

→ **Project**: an extended tasks in which the learner is expected to select appropriate content to solve context-based problem.

→ **Research task**: it involves collection of data and/or information to solve a problem or to understand a particular set of circumstances and/or phenomena.

7.11.3 Outcomes-Based Assessment tools

In short, the assessment tools used will be dictated by the nature of the task and the focus of assessment. Assessment tools could include one or a combination of rubrics, checklists, observation schedules and memoranda (DoE, 2005a:11).

7.11.4 End-of-year exam

The end of year exam paper is conducted as indicated in paragraph 6.4.6.

7.11.5 Assessment in Grade 12

Paragraph 6.4 explains the components of assessment in Grade 12. The annual assessment plan is similar to that for Grade 10 – 11, except that in Grade 12 the trial examination is written during the third term (Table 7.6). The programme of assessment comprises seven tasks that are internally assessed (DoE, 2005a:13).

Table 7.6 Programme of Assessment (Grade 12) (DoE, 2005a:9)

PROGRAMME OF ASSESSMENT			
ASSESSMENT TASKS (25%)			**End of year assessment (75%)**
TERM 1	**TERM 2**	**TERM 3**	**TERM 4**
Practical investigation	Practical investigation	Research project	Final Examination
Control test	Mid-year examination	Control test	
		Trial Examination	

7.12 Promotion in FET Schools

According to the NCS (Assessment Guidelines policy) (DoE, 2007:16), for a learner to be promoted and for certification purposes, s/he should at least achieve a level 2 rating (Elementary achievement: 30 - 39%) in Physical Sciences. This is subject to the requirement that a learner must achieve at least a level 3 rating (Moderate achievement: 40-49%) in at least one of the three choice subjects (DoE, 2007:16). These ratings correspond with the Physical Sciences Assessment Taxonomy (Table 7.8). According to these rating codes, rating code 1 has a rating of not achieved, which is equivalent to 0-29%. The explanation for this is that the learner simply supplies bits of unconnected information that have no organisation and make no sense beyond the issue listed. Rating code 2 is equivalent to the level 1 (Recall/Knowledge) of the Assessment Taxonomy that corresponds with the Bloom's Taxonomy Table. Table 7.7 below indicates the seven-point scale for reporting learners' achievement. The last column (column 4) indicates the relationship between the seven-point scale and the Taxonomy of Educational Objectives and/or Assessment Taxonomy.

Table 7.7 Seven-Point Scale for achievement (DoE, 2007:16)

RATING CODE	RATING	MARKS %	DESCRIPTION OF COGNITIVE LEVEL
7	Outstanding achievement	80 – 100	Evaluation
6	Meritorious achievement	70 – 79	Synthesis
5	Substantial achievement	60 – 69	Analysis
4	Adequate achievement	50 – 59	Application
3	Moderate achievement	40 – 49	Comprehension
2	Elementary achievement	30 – 39	Recall
1	Not achieved	0 – 29	

TABLE 7.8 PHYSICAL SCIENCES ASSESSMENT TAXONOMY (DoE, 2007:17)

DESCRIPTION OF COGNITIVE LEVELS	EXPLANATION	SKILLS DEMONSTRATED	ACTION VERBS
EVALUATION	At the extended abstract level, the learner makes connections not only within the given subject area, but also beyond it, and generalises and transfers the principles and ideas underlying the specific instances. The learner works with relationships and abstract ideas.	• Compares and discriminates between ideas. • Assesses value of theories, presentations. • Makes choices based on reasoned arguments. • Verifies value of evidence. • Recognises subjectivity.	Assess, decides, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarise, critique, appraise, interpret, justify
SYNTHESIS	The learner works at the extended abstract level (see level 6 above), but makes errors because s/he is insufficiently informed at more modest levels.	• Uses old ideas to create new ones. • Generalises from given facts. • Relates knowledge from several areas. • Predicts and draws conclusions.	Combine, integrate, modify, rearrange, substitute, plan, create, design, invent, compose, formulate, prepare, generalise, rewrite, categorise, combine, compile, reconstruct, generate, organise, revise, what if?
ANALYSIS	The learner appreciates the significance of the parts in relation to the whole. Various aspects of the knowledge become integrated; the learner requires deeper understanding and ability to break down a whole into its component parts. Elements embedded in a whole are identified and the relations among the elements are recognised.	• Sees patterns and the organisation of parts. • Recognises hidden meanings. • Identifies of components.	Analyse, separate, order, explain, connect, classify, arrange, divide, compare, select, infer, break down, contrast, distinguish, diagram, illustrate, identify, outline, point out, relate.
APPLICATION	The learner establishes a relational construct (see level 5 above), but which has errors. The learner has the ability to use (or apply) knowledge and skills in new situations.	• Uses information, methods, concepts and theories in new situations. • Solves problems using required skills or knowledge.	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, manipulate, prepare, produce
COMPREHENSION	A number of connections may be made, but the meta-connections are missed, as is their significance for the whole. The learner has first level understanding, recalls and understands information and describes meaning.	• Understands information and grasps meaning. • Translates knowledge into new contexts and interprets facts. • Compares, contrasts, orders, groups and infers causes and predicts consequences.	Summarise, describe, interpret, contrast, predict, associate, discuss, extend, comprehend, convert, defend, explain, generalise, give example, rewrite, infer
RECALL	Simple and obvious connections are made. The learner recalls and remembers facts.	• Observes and recalls information.	List, define, tell, describe, identify, show, know, label, collect, select, reproduce, match, recognise, examine, tabulate, quote, name

In order to understand the implication of each rating, Table 7.7 should be read in conjunction with Table 7.8, where, for example, if the learner has a rating code of 5, it means the learner has attained something between 60 and 69%. This corresponds with level 4 of the Taxonomy of Educational Objectives (i.e. analysis). This means that such a learner has successfully demonstrated all or most of the skills within level 4 (analysis) of Bloom's Taxonomy. This is the indication of the importance of a well-balanced assessment task.

7.13 Conclusion

The chapter indicates that the process of articulating learners' outcome statements within the general movement of Outcomes-Based Assessment has the Taxonomy of Educational Objectives as its forerunner. As indicated in paragraph 7.7, the key similarity between the two is their hierarchical structure, which can be seen as a component analysis of educational outcomes at successive finer levels of the scale to the point where these are observable (Andrich, 2002:57). It is, therefore, imperative that teachers teach and assess things that are important. A systematic application of any of the taxonomies discussed in this chapter will help to identify what really is important in any course of study (Killen, 2004:84).

In the next chapter (Chapter 8) the research design and methodology that will be followed in the empirical part of the research will be discussed.

CHAPTER 8

Research design and methodology

8.1 Introduction

The previous chapters (Chapter 2-7) provided a literature study that explored the key concepts, fundamental principles and the philosophy underpinning OBE. The study also compared the traditional approach and effect of OBE on teaching, learning and assessment. Chapter 3 of the literature study focused specifically on the assessment of Physical Sciences in the Further Education and Training (FET) Band.

In order to understand the situation regarding the Outcomes-Based Assessment (OBA) of Physical Sciences in public schools of the North-West Province of the Republic of South Africa, an empirical investigation was conducted. In this chapter the research design and methodology that was followed in the empirical part of the research will be discussed.

8.2 Problem statement

For the purpose of this study, the following primary and secondary research questions were formulated:

8.2.1 Primary research question

- What assessment model can be proposed to facilitate the effective assessment of Physical Sciences in the FET Band by considering both the literature and the practical experiences of teachers in the North-West Province?

8.2.2 Secondary research questions

- What does the literature reveal about the elements of OBA of Physical Sciences in the FET Band?
- How do teachers in the North-West province experience OBA of Physical Sciences in FET Band
- What are the challenges or obstacles that these respondents experience with OBA of Physical Sciences in the FET Band?
- What sources/opportunities are there to support the OBA of Physical Sciences in the FET Band?
- Is there a relationship between teacher variables and the OBA of Physical Sciences in the FET Band?

- What assessment model can be proposed to facilitate the effective implementation of Physical Sciences in the FET Band?

8.3 Research Aim and Objectives

8.3.1 Research aim

- The overarching research aim was to develop an assessment model that can facilitate the effective assessment of Physical Sciences in the FET Band for secondary schools in the North-West Province?

8.3.2 Research objectives

The research objectives were to:

- explore the key concepts, fundamental principles and philosophy underpinning OBE and OBA of Physical Sciences in the FET Band;
- determine how teachers in the North-West Province experience Outcomes-Based Assessment of Physical Sciences in the FET Band;
- identify the challenges or obstacles that these teachers experience with regard to the OBA of Physical Sciences in the FET Band;
- determine what sources/opportunities are available to support the OBA of Physical Sciences in the FET Band;
- determine whether a relationship exists between teacher variables and the OBA of Physical Sciences in the FET Band.

8.4 Research design and methodology

8.4.1 Research design

In order to answer the research questions and achieve the research aim and objectives, a survey was conducted by means of a questionnaire (see Appendix F and paragraph 8.4.4 below for more information about the questionnaire). Surveys offer versatile, credible information about a large number of people that can be inferred from responses obtained from a small group of subjects, and also allow for generalisability across the population (McMillan and Schumacher, 2010:4 and 236).

8.4.2 Research methodology

In the pragmatic paradigm there is a belief that the scientific method itself is insufficient. Common sense and practical thinking are rather used to determine the best approach, depending on the purpose of the study and contextual factors (McMillan and Schumacher, 2010:6). As the intended consequence of this research was to develop an effective OBA model, it was important to know what challenges or obstacles these participants experienced with the implementation of OBA, what sources or opportunities were available, whether a relationship existed between teacher variables and the OBA of Physical Sciences in the FET Band and how all these could be used to develop an effective OBA of Physical Sciences in the FET Band. Based on the purpose of this research and as supported by a pragmatic world view, both quantitative and qualitative methods of data collection and analysis were used, with more emphasis on the quantitative method.

The concurrent triangulation strategy used in this research means that both quantitative and qualitative data were collected concurrently and then the two databases were integrated. Priority was given to the quantitative approach. The discussion section first provided the quantitative statistical results, followed by the qualitative quotes that confirm the quantitative results. In such a case, the strength of one adds to the strength of the other (Creswell, 2009:213).

This design, usually referred to as mixed method research, enables the researcher to look to many approaches for collecting and analysing data rather than subscribing to only one way. It enables the researcher to use all approaches available to understand the teachers' challenges with OBA of Physical Sciences in FET Band and to derive knowledge about such challenges (Creswell, 2009:10 – 11).

Through its quantitative approach, the relationship among variables were examined, measured and subsequently number data were analysed using statistical procedures, while the qualitative approach enables the researcher to focus on individual meaning, and the importance of rendering the complexity of a situation (Creswell, 2009:4).

8.4.3 Study population and selection of participants

A list of names and contact details of all FET Band public schools in the North-West Province was obtained from the North-West Education Department. The North-West Education Department is made up of 4 Regional Offices, each with a number of Area Provincial Offices (APOs). There was a population of 369 FET Band public schools registered for the National Senior Certificate (NSC). Of the 369 schools, 39 public schools do not offer Physical Sciences up to Grade 12 and 330 do.

The systematic sampling method was used to insure that each school in the population had an equal chance to be sampled from the list of 330 schools offering Physical Sciences in the North-West Province. This method yielded a sample of 75 schools. The services of Statistical Consultation Services of the North-West University (Potchefstroom Campus) were utilised to draw the sample. At each of these schools, any teacher who taught Physical Sciences in the FET Band from 2007 was invited to participate in the survey on a voluntary basis (see Appendix E). In Table 8.1 below, information can be found about the number of schools that was included in the sample per region and the number of participants that responded to the questionnaire.

TABLE 8.1: Number of schools per region and the number of participants who responded to the questionnaire

Regional Office	**Number of Schools (Sample)**	**Number of participants who responded to the questionnaire (N = 72)**	**Response rate**
Bojanala Platinum	42	24	61.9%
Dr. Kenneth Kaunda	21	16	76.2%
Dr. R.S. Mompati	21	14	66.7%
Ngaka Modiri Molema	27	18	66.7%
TOTAL	**111**	**74**	**66.7%**

8.4.4 The data collection instrument

This research intends to systematically gather and analyse data concerning Physical Sciences teachers' experience with OBA of Physical Sciences in the FET Band schools. For the purposes of data collection a questionnaire was developed (see Appendix F).

8.4.4.1 The development of the questionnaire

For the purposes of gathering biographical information from the participants, Section A of the questionnaire was developed.

The theoretical part of the research (Chapter 2 – 7) with particular references to OBE and departmental assessment policy documents, i.e. OBE and NCS policy documents (DoE, 2005a; 2005b; 2003a; 2003b) served as a theoretical basis for developing the contents of Section B of the questionnaire, which dealt with teachers' experiences of OBA.

The questionnaire consisted of 91 structured (closed) and 10 open-ended items (i.e. 101 items). These items were divided into two sections. Section A consisted of 16 closed items (items 1 – 16) that gathered biographical information from the participants. Section B consisted of 75 closed items (items 17 – 91) that evoked quantitative responses from the participants and 10 open-ended items that invited participants to share their personal (qualitative) experience of the OBA of Physical Sciences in the FET Band. The different sub-sections of Section B are described below:

- Sub-section B1 dealt with the participants' experiences of OBA training and their confidence to implement OBA. Five closed items (items 17 – 21) and 2 open-ended items (items 1B1 & 2B1) were included in this sub-section.
- Sub-section B2 dealt with participants' views of the NCS documentation and 17 closed items (items 22 – 38) and one open-ended item (item 1B2) were included in this sub-section.
- Sub-section B3 consisted of statements on OBA (departing from an OBE perspective) where participants had to respond to five closed items (items 39 – 43) that were included in this sub-section.
- Sub-section B4 dealt with different aspects concerning the assessment of Physical Sciences in the FET Band and thirty-six closed items (items 44 – 79) were included in this sub-section.
- Sub-section B5 dealt with experiments and practical work and the participants were requested to respond to twelve closed items (items 80 – 91) and 5 open-ended items (items 1B1 – 5B5).
- Sub-section B6: Participants were invited to give qualitative responses (further comments and suggestions about the OBA of Physical Sciences in the FET Band) to these open-ended items (items1B6 & 2B6).

8.4.4.2 Validity and reliability of the questionnaire

Validity is an integrated evaluation judgement of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores or other modes of assessment (Black, 2003:814; Klassen, 2006:841 and Killen, 2003:1). Simply put, validity refers to whether an instrument actually measures what it was designed to measure (Field, 2009:11). There are different types of validity, i.e. construct validity, content validity and face validity.

Construct validity refers to inferences that are made from the nature of the measurement and interventions used for the constructs they purportedly represent (McMillan and Schumacher, 2010:15). According to Killen (2003:4) constructs are theoretical conceptual frameworks for describing human characteristics, behaviours or groups of abilities. Construct validity is essentially concerned with investigating the meaning of test scores. It is based on the idea that a score on a well-constructed test can be taken as one (of possibly many) indicators of the construct of interest (Killen, 2003:3). Simply put, construct validity refers to confounding or misunderstanding the variables in research (Wiersma and Jurs, 2005:77). It deals with the definitions of the independent and dependent variables, their clarity and unambiguous identification of constructs. Thus, care must be taken in defining the variables so that others can replicate the study or extend it to different populations or settings (Wiersma and Jurs, 2005:104 and 105).

To ensure construct validity, the theoretical research (Chapters 2 – 7), with particular reference to OBE and departmental assessment policy documents, served as a theoretical basis for developing the contents of the questionnaire that dealt with teachers' experiences of OBA. Furthermore, mixed method was also used to reduce the mono-method bias (i.e. limitation based on a single way of measuring variables) (McMillan and Schumacher, 2010:116).

According to Killen (2003:3) content validity is an indication of how relevant the content of a test or assessment task is, and how representative it is of the domain that is purported to be tested. It is essentially this concept of content validity that leads to claims such as "validity defines whether a test or item measures whatever it has to measure" (Killen, 2003:3). In order to ensure that the questionnaire adheres to the content validity, several consultations were held with the promoter, who is a specialist in the field of OBA and the contents of the questionnaire.

McMillan and Schumacher (2010:175) explain face validity to be a judgement that the items of a questionnaire appears to be relevant. For that reason, a small pilot study was conducted with the preliminary questionnaire among students at the NWTO (Natuurwetenskappe Onderwys) who are Physical Sciences teachers in the FET Band and who are busy with further in-service training courses at the NWU (Potchefstroom Campus). These students were not part of the survey, and for that reason they were asked to comment and make suggestions about aspects of the questionnaire related to: the user-friendliness of the questionnaire (clarity of instructions and items, length of the questionnaire, types of items) and whether in their opinion the questionnaire dealt with aspects of OBA of Physical Sciences in the FET Band that they deemed as important or relevant. Item analysis was conducted to identify those items that the teachers experienced difficulties with, or that they did not answer, or where a very uniform response pattern was detected. After the result analysis and the teachers' suggestions and comments were considered, the item was finalised.

All the structured (closed) items (item 44 to 79) in sub-section B4 of the questionnaire dealt with the effective assessment of Physical Sciences in the FET Band and were divided into four (4) aspects, namely: designing assessment activities; aims of effective OBA activities; principles of high quality assessment; and Outcomes-Based Assessment strategies. In order to determine the construct validity of

Sub-section B4 of the questionnaire, confirmatory factor analyses utilizing a principal axis factoring rotation method (Oblimin with Kaiser Normalization) were conducted (see paragraph 9.6 in Chapter 9).

All the structured (closed) items (items 80 to 91) in Sub-section B5 of the questionnaire dealt with participants' experiences with regard to the assessment of experiments and other practical work in the FET Band. Confirmatory factor analyses were also conducted to determine the construct validity of Sub-section B5 of the questionnaire (see par. 9.7 in Chapter 9).

Validity is a necessary but not sufficient condition of a measure. A second measurement is reliability, which is the ability of the measure to produce the same results under the same conditions (Field, 2009:12 and Killen, 2003:2). The more reliable a test is, the more confidence we can have that the scores obtained from the administration of the test are essentially the same score that would be obtained if the test were re-administered. There are different types of reliability, but for this study only internal consistency reliability was observed with the calculation of Cronbach's alpha coefficients. Cronbach's alpha determines the agreement of answers on questions targeted at a specific trait. It should be reported for every total and for each subscale score that is used as a variable (McMillan and Schumacher, 2010:182).

According to Field (2009:674), the simplest way to determine the internal consistency of the scale is to use split-half reliability, where a data set is randomly split into two and a score for each participant's is then calculated based on each half. The correlation between the two halves is the statistic computed in the split-half method, with large correlations being a sign of reliability. The average of these values is equivalent to Cronbach's alpha, α.

Cronbach's α is:

$$\alpha = \frac{N^2 \overline{Cov}}{\sum s^2_{item} + \sum Cov_{item}}$$

In order to determine the reliability of Sub-section B4 and B5 of the questionnaire, Cronbach's alpha coefficients were calculated (see Tables 9.47 and 9.48 in Chapter 9).

8.4.5 Data collection procedure

The researcher also wrote a letter to the Physical Sciences Subject Advisors requesting their assistance with the distribution and collection of the questionnaire (see Appendix D). To compensate for a lack of responses, 111 questionnaires were delivered to the Area Provincial Offices (APOs) by the researcher for distribution by the Subject Advisors, who are in direct contact with the Physical Sciences teachers at the selected schools.

After two months from delivery, **50** of the questionnaire **(45.0%** of the questionnaires**)** were collected from the APOs by the researcher, **22** questionnaires **(19.8%** of the questionnaires**)** were delivered to the researcher by Subject Advisors. The researcher also made phone calls to the principals of selected schools in an effort to collect more questionnaires, and **two** more questionnaires **(1.8%** of the questionnaires**)** were returned to the researcher in the self-addressed envelopes that were sent to the schools. In total **74** of the **111** questionnaires (response rate = **66.7%)** were returned to the researcher (see Table 8.1).

8.4.6 Data analysis

In the paragraph below, information is given about the quantitative and qualitative data analysis.

8.4.6.1 Quantitative data analysis

The quantitative data were captured by a data typist at Statistical Consultation Services of the NWU (Potchefstroom Campus). Further statistical analysis and interpretation were done by a senior statistician at the same department (see Appendix H for a letter in confirmation in this regard).

Participants' responses to Section A (biographical details) and to structured (closed) items of Section B of the questionnaire were tabulated and presented as frequencies and percentages (see paragraph 9.2.1 and 9.3 of Chapter 9).

The construct validity of Sub-sections B4 and B5 of the questionnaire was determined by means of confirmatory factor analyses utilizing a principal axis factoring rotation method (Oblimin with Kaiser Normalization) (see paragraph 9.6 and 9.7 in Chapter 9). Cronbach's alpha coefficients were calculated to determine the reliability of Sub-sections B4 and B5 of the questionnaire (see Tables 9.47 and 9.47 in Chapter 9).

In order to determine whether significant relationships existed between the different biographical variables and factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band, the following statistical methods were used: independent t-tests and analyses of variance (ANOVA's) (see paragraph 9.11 Chapter 9).

Independent t-tests were applied in cases where biographical variables contained two response categories such as gender, school location and possession of science apparatus. In order to determine whether statistically significant differences existed, p-values ($p < .05$) were consulted. Effect sizes (Cohen's d – values) were then calculated to determine the practical significance of the difference (Cohen, 1988).

In cases where biographical variables contained more than two responses categories, for example in the case of age (20 – 35 yrs, 36 – 40 yrs, 41+ yrs) ANOVA was used to determine whether statistical and practical significances existed. The omnibus test was initially used to determine whether statistically significant relationships existed between the different age categories and factors that contributed towards effective implementation of OBA of Physical Sciences in the FET Band. In this regard p-value smaller than .05 were regarded as statistically significant. Post-hoc test tests were done to determine whether relationships were of practical significance and Cohen's d-values were then calculated to determine the practical significance.

8.4.6.2 Qualitative data analysis

Verbatim transcriptions were made of participants' responses to the open-ended items of the questionnaire (see Appendix G). These transcriptions were analysed by means of content analysis and the process is described below (Creswell, 2009:185 - 186):

- Collecting open-ended data;
- Transcription of raw data;
- Organising and preparing data for analysis;
- Reading through all the data to obtain a general sense of information;
- Developing categories on the basis of emerging information collected from participants;
- Categorising together similar responses to an item of a sub-section;
- Finding the most descriptive wording for the category;
- Making a final decision on the description of the category;
- Assembling the data material belonging to each category in one place;
- Description of responses; and
- Interpreting the responses.

These steps were undergone to analyse the qualitative data.

8.5 Ethical consideration

Permission to conduct research was requested from the North-West Education Department as well as from the principals of the selected schools (see Appendices A and C). The researcher also wrote a letter to the participants (see Appendix E) in which they were informed about the nature and purpose of the research, as well as the ethical considerations that guided the research. This letter was attached to the questionnaire and on this basis the participants gave informed consent for participating in the research.

The researcher abided by the following ethical considerations:

- Participation was completely voluntary;
- Participants could withdraw from the research at any stage;
- Participants participated anonymously and no person or institution were identified in the research report;
- Information given by participants was treated confidentially;
- Participation did not result in any form of physical or psychological discomfort;
- Participation did not impact negatively on participants' work, family or other social obligations;
- Completed questionnaires and data sets will be kept in safekeeping at the NWU for a period of seven years.

8.6 Conclusion

This chapter offered a discussion of the research design and methodology. In the following chapter (Chapter 9), the results emanating from the empirical part of the research will be presented and discussed.

CHAPTER 9

RESULTS AND CONCLUSIONS

9.1 Introduction

In Chapter 8 the method of research was discussed. The quantitative and qualitative results emanating from the research will be presented and discussed in this chapter. On the basis thereof conclusions will be drawn with regard to the primary and secondary research questions stated in Chapter 8 (see paragraphs 8.2.1 and 8.2.2).

9.2 Quantitative results

The quantitative results emanating from the survey will be presented in three sections. The first two sections deal with the participants' biographical details and their responses to the structured items of Section B of the questionnaire, and will be presented in the form of frequency tables. The subsequent section deals with the validity and reliability of Sections B4 and B5 of the questionnaire. Factor analyses were done for these items and Cronbach's Alpha coefficients were calculated. Lastly the relationship between certain biographical and situational variables and factors related to assessment of Physical Sciences in the FET Band were investigated. For this purpose ANOVA's and t–tests were conducted.

9.2.1 Participants' responses to the structured items of Section A (Biographical Information)

Seventy-two participants completed the questionnaire and their biographical details are presented in Table 9.1 to 9.15 below:

Table 9.1: Participants' gender

Item	Gender	Frequency	Percentage
1	Male	38	52.78
	Female	34	47.22
	TOTAL	**72**	**100**

Almost the same number of female and male teachers who teach Physical Sciences in the FET Band completed the questionnaire.

Table 9.2: Participants' age

Item	Age in years	Frequency	Percentage
2	20 -25 yrs	2	2.28
	26 – 30 yrs	5	7.04
	31 -35 yrs	14	19.72
	36 – 40 yrs	23	32.39
	41 – 50 yrs	23	32.39
	51 – 60 yrs	2	2.82
	61 + yrs	2	2.82
	TOTAL	**71***	**100**

*Frequency missing = 1

Most of the teachers (64.78%) who teach Physical Sciences in FET Band are mature teachers (36 to 50 yrs old) and can therefore, in terms of their age, be regarded as experienced teachers.

Table 9.3: Participants' overall teaching experience

Item	Overall teaching experience in years	Frequency	Percentage
3	1 yr	1	1.39
	2 – 5 yrs	10	13.89
	6 – 10 yrs	14	19.44
	11 – 15 yrs	23	31.94
	16 – 20 yrs	11	15.28
	21 – 30 yrs	12	16.67
	30 + yrs	1	1.39
	TOTAL	**72**	**100**

Most of the teachers (84.72%) have more than 5 years of teaching experience and can therefore be regarded as experienced teachers.

Table 9.4: Participants' teaching experience as Physical Sciences teachers in the FET Band

Item	Teaching experience as a Physical Sciences teacher in FET	Frequency	Percentage
4	1 yr	4	5.56
	2 – 5 yrs	20	27.78
	6 – 10 yrs	17	23.61
	11 – 15 yrs	15	20.83
	16 – 20 yrs	8	11.11
	21 – 30 yrs	7	9.72
	More than 31 yrs	1	1.39
	TOTAL	**72**	**100**

Most of the teachers (66.66%) have more than 5 years teaching experience in Physical Sciences in the FET Band and can therefore be regarded as teachers with adequate experience of teaching the subject to learners in the particular Band.

Table 9.5: Participants' highest teaching qualifications

Item	What is your highest teaching qualification?	Frequency	Percentage
5	Teaching certificate	1	1.43
	Teacher diploma	17	24.29
	Teaching degree	17	24.29
	B-degree + Teaching diploma	13	18.57
	Hons. Degree/ B.Ed. Hons	19	27.14
	M.Degree + Teaching Diploma	3	4.29
	Ph.Degree + Teaching diploma	0	0.0
	TOTAL	**70****	**100**

**Frequency missing = 2

Most of the participants (74.28%) hold a teaching degree and higher teaching qualifications. It can therefore be deduced that the majority of teachers are well-qualified in terms of their qualifications.

Table 9.6: Participants' highest qualification in Physical Sciences

Item	What is your highest qualification in Physical Sciences/Physics/Chemistry?	Frequency	Percentage
6	Grade 12	1	1.43
	1st Year tertiary level	2	2.86
	2nd Year tertiary level	25	35.71
	3rd Year tertiary level	36	51.43
	Hons. Degree	5	7.41
	Masters Degree	1	1.43
	Doctors Degree	0	0.0
	TOTAL	**70****	**100**

**Frequency missing = 2

The majority of the participants (60.2%) hold a third year and higher tertiary qualification in Physical Sciences (Physics/Chemistry). One can thus accept that most of the participants are adequately qualified to teach the subject to learners in the FET Band.

Table 9.7: Participants' position at school

Item	What is your position at your school?	Frequency	Percentage
7	Teacher	45	62.50
	Head of department	23	31.94
	Deputy Principal	2	2.78
	Principal	2	2.78
	TOTAL	**72**	**100**

The majority of the participants hold positions as teachers.

Table 9.8: Location of the school

Item	Is your school situated in a rural or urban area?	Frequency	Percentage
8	Rural	54	76.06
	Urban	17	23.94
	TOTAL	**71***	**100**

*Frequency missing = 1

The majority of the participants (76.06%) teach at rural schools.

Table 9.9: Availability of the electricity at the school

Item	Is electricity available at your school?	Frequency	Percentage
9	Yes	71	98.61
	No	1	1.39
	TOTAL	**72**	**100**

With the exception of one school, all the schools have electricity.

Table 9.10: Availability of running water at the schools

Item	Is running water available at your school?	Frequency	Percentage
10	Yes	69	95.83
	No	3	4.17
	TOTAL	**72**	**100**

With the exception of three schools, all the other schools have running water.

Table 9.11: Grade(s) that participants teach Physical Sciences to

Item	Which grade/s do you teach Physical Sciences to?	Frequency	Percentage
11	Grade 10 only	2	2.82
	Grade 11 only	1	1.41
	Grade 12 only	7	9.86
	Grade 10 & 11	2	2.82
	Grade 11 & 12	5	7.04
	Grade 10 – 12	54	76.06
	TOTAL	**71***	**100**

*Frequency missing = 1

The majority of the participants (76.06%) teach Physical Sciences from Grade 10 to 12.

Table 9.12: Average number of learners in Physical Sciences class

Item	The average number of learners in your Physical Sciences class is:	Frequency	Percentage
12	10 – 20	17	23.94
	21 – 30	15	21.13
	31 – 40	13	18.31
	41 – 50	22	30.99
	51 – 60	3	4.23
	61 -70	1	1.41
	TOTAL	**71***	**100**

*Frequency missing = 1

Most participants (63.37%) teach to classes with less than 40 learners. Thus, in the majority of the cases, overcrowding does not seem to be a problem.

Table 9.13: Availability of science laboratory at the schools

Item	Does your school have a science laboratory?	Frequency	Percentage
13	Yes	48	66.67
	No	24	33.33
	TOTAL	**72**	**100**

Most schools have science laboratories.

Table 9.14: Availability of apparatus to do practical work (experiments)

Item	Do you have apparatus to do practical work (experiments) in your Physical Science classroom?	Frequency	Percentage
14	Yes	63	87.50
	No	9	12.50
	TOTAL	**72**	**100**

Most schools have apparatus to conduct practical work (experiments) in their Physical Sciences classrooms.

Table 9.15: Types of apparatus that the schools have

Item	If you have apparatus at your school, which apparatus do you have?	Frequency	Percentage
15	Standard science apparatus	19	26.76
	Somerset Micro-kits	19	26.76
	Student-Lab Small-Scale Set	16	22.54
	None	6	8.45
	All	4	5.63
	Somerset Micro-kits and Student-Lab Small-Scale set	4	5.63
	Standard science apparatus and either Somerset or Small-scale set	3	4.23
	TOTAL	**71***	**100**

*Frequency missing = 1

Most schools (92%) are equipped with the necessary science apparatus.

Table 9.16: Language of instruction to teach Physical Sciences

Item	Which medium of instruction do you use to teach Physical Sciences at your school?	Frequency	Percentage
16	English	54	75.0
	Afrikaans	4	5.56
	Alternating between English and Afrikaans	2	2.78
	Alternating between English and Setswana	12	16.67
	One of the other official languages	0	0.0
	TOTAL	**72**	**100**

Most of the participants use English as the medium of instruction to teach Physical Sciences at their schools.

9.2.2 SUMMARY OF THE PARTICIPANTS' BIOGRAPHICAL INFORMATION

The biographical details of the participants as listed on Table 9.1 (item 1 – 16) indicate that:

- Almost the same number of male and female teachers participated in the survey.
- The majority of the participants are mature and experienced teachers.
- Most of the participants who teach Physical Sciences in the FET Band are suitably qualified.
- The majority of the participants hold teaching positions.
- Most of the participants teach at rural schools.
- With the exception of respectively one and three schools, all the other schools have electricity and running water.
- The majority of the participants teach Physical Sciences from grade 10 to 12.
- Most of the participants teach Physical Sciences in classes with less than 40 learners.
- Most of the schools have science laboratories and the necessary apparatus to conduct practical work; and
- English is the medium of instruction used by most participants.

From the demographic profile of the participants, it can be deduced that in terms of their teaching experience and qualifications, the respondents are able to contribute meaningfully and reliably to the survey. Furthermore, it seemed as if negative factors such as classroom overcrowding and infra-structural deficits that could impact negatively on the teaching, learning, and assessment situations are largely absent.

9.3 PARTICIPANTS' RESPONSES TO THE STRUCTURED (CLOSED) ITEMS OF SECTION B IN THE QUESTIONNAIRE

The following tables present participants' responses to the structured items on Section B of the questionnaire. Some participants did not respond to some of the items and therefore the table totals do not always add up to 72. An asterisk (*) will be used to indicate the number of participants that did not respond to a particular item.

9.3.1 Participants' responses to items related to OBA training and teachers' confidence to implement OBA

Information regarding participants' training in OBA is presented in Tables 9.17 to 9.21.

Table 9.17 Did you receive training in OBA? (Item 17)

Response	Yes	No	Total
Frequency	58	14	**72**
Percentage	80.56	19.44	**100**

The results in Table 9.17 indicate that the majority of the participants received training in the implementation of OBA.

Table 9.18 For how long did you receive training in OBA? (Item 18)

Responses	A few hrs	1 day	2 days	+ 2 days	1 week	+ 1 week	N/A	Total
Frequency	9	2	8	13	15	13	12	**72**
Percentage	12.50	2.78	11.11	18.06	20.83	18.06	16.67	**100**

Table 9.18 indicates that 38.89% of the participants received training in the implementation of OBA for a period of one week and longer, 44.45% received less than a week's training. 16.67% did not receive any training at all.

Table 9.19 At what level was the OBA training presented? (Item 19)

Responses	School	Area office	Regional	Provincial	National	Union	Other institution	Total
Frequency	4	43	2	8	0	0	5	**62******
Percentage	6.45	69.51	3.23	12.90	0.00	0.00	8.06	**100**

****Missing responses = 10

Table 9.19 indicates that 91.94% of the participants received their training in OBA of Physical Sciences from the Department of Education (69.51% at Area Office level, 12.90% at Provincial level, 6.45% at School level and 3.23% at Regional level) and 8.06% received their training from other institutions.

Table 9.20 How do you rate the standard of OBA training that you have received? (Item 20)

Responses	Very poor	Poor	Above average	Good	Very good	N/A		Total
Frequency	2	9	21	25	3	10	2	**72**
Percentage	2.78	12.50	29.17	34.72	4.17	13.89	2.78	**100**

Most of the participants (68.06%) rated the standard of training in OBA as above average to very good, while 15.28% rated the standard of their OBA training as poor to very poor.

Table 9.21 How confident are you to implement OBA? (Item 21)

Response	**Not confident at all**	**Little confidence**	**Confident**	**Very confident**	**Total**
Frequency	5	9	52	5	**71***
Percentage	7.04	12.68	73.24	7.04	**100**

*Frequency missing = 1

Table 9.21 indicates that the majority of the participants (80.28%) are confident to very confident to implement OBA, whereas 19.72% reported little or no confidence at all to implement OBA.

Synthesis

Based on the participants' responses to items related to their OBA training and their confidence to implement OBA, the following deductions can be made:

- Most participants received OBA training.
- The duration of their training was relatively short.
- The Department of Education presented most of the training.
- In general, the quality of the training seemed to be satisfactory.
- Most of the participants are confident to implement OBA.

9.3.2 Participants' responses to NCS documents (Grades 10 – 12)

Information with regard to participants' responses to NCS documents can be found in Tables 9.22 to 9.25 below:

Table 9.22 Which of the following document(s) are you familiar with? (Items 22 – 26)

NCS Documents		Yes	No	Not sure	Total
Learning Programme Guidelines	**Frequency**	69	2	1	**72**
	Percentage	95.83	2.78	1.39	**100**
Subject statement	**Frequency**	68	1	3	**72**
	Percentage	94.44	1.39	4.17	**100**
Subject assessment guidelines	**Frequency**	69	2	1	**72**
	Percentage	95.86	2.78	1.39	**100**
Assessment policy framework	**Frequency**	63	5	4	**72**
	Percentage	87.50	6.94	5.56	**100**
Examination guidelines	**Frequency**	71	1	0	**72**
	Percentage	98.61	1.39	0.00	**100**

Table 9.22 indicates that the largest majority of the participants (87.50% up to 98.61%) are familiar with all the NCS documents.

Table 9.23 Which of these documents are available to all teachers at your school? (Items 27 – 31)

NCS Documents		Yes	No	Not sure	Total
Learning Programme Guidelines	**Frequency**	63	3	5	**71***
	Percentage	88.73	4.23	7.04	**100**
Subject statement	**Frequency**	63	2	6	**71***
	Percentage	88.73	2.82	8.45	**100**
Subject assessment guidelines	**Frequency**	64	2	4	**70****
	Percentage	91.43	2.86	5.71	**100**
Assessment policy framework	**Frequency**	61	6	4	**71***
	Percentage	85.92	8.45	5.63	**100**
Examination guidelines	**Frequency**	70	0	2	**72**
	Percentage	97.22	0.00	2.78	**100**

*Missing response = 1

**Missing responses = 2

It is clear from the previous table that the NCS documents are available to most of the participants.

Table 9.24 Which of these documents do you personally have a copy of? (Items 32 – 36)

NCS Documents		Yes	No	Not sure	Total
Learning Programme Guidelines	**Frequency**	66	2	3	**71***
	Percentage	92.96	2.82	4.23	**100**
Subject statement	**Frequency**	67	4	1	**72**
	Percentage	93.06	5.56	1.39	**100**
Subject assessment guidelines	**Frequency**	68	3	0	**71***
	Percentage	95.77	4.23	0.0	**100**
Assessment policy framework	**Frequency**	58	9	4	**71***
	Percentage	81.69	12.68	5.63	**100**
Examination guidelines	**Frequency**	71	1	0	**72**
	Percentage	98.61	1.39	0.0	**100**

*Missing response = 1

Most of the participants personally had all the NCS documents.

Table 9.25 What is your opinion of the above NCS documents? (Item 37 – 38)

Response		Yes	No	N/A	Total
They are easy to understand	**Frequency**	65	5	2	**72**
	Percentage	90.28	6.94	2.78	**100**
They contain clear guidelines for implementation	**Frequency**	61	8	2	**71***
	Percentage	85.92	11.27	2.82	**100**

*Missing response = 1

Table 9.25 indicates that most of the participants find the NCS documents easy to understand and feel that they contain clear guidelines for implementation.

Synthesis

Based on the participants responses to the items related to NCS documents, the following deductions can be made:

- Most of the participants are familiar with the different NCS documents.
- Most of the NCS documents are available to all the teachers in their schools.

- Most of the participants have a personal copy of all these documents in their possession.
- Most of the participants find these documents easy to understand and are of the opinion that they contain clear guidelines for implementation.

9.3.3 Participants' responses to statements on OBA departing from an OBE perspective

In Table 9.26 to 9.30, the participants' responses to statements departing from an OBE perspective are presented.

Table 9.26 Assessment is primarily the teacher's task (Item 39)

Responses	Totally disagree	Do not agree	Agree	Agree completely	Total
Frequency	8	15	34	11	**68******
Percentage	11.76	22.06	50.00	16.18	**100**

****Missing responses = 4

According to Table 9.26, most of the participants (66.18%) "agreed and agreed completely" that assessment is primarily the teacher's task, whilst 33.82% were in disagreement of the statement.

Table 9.27 Assessment is a new concept that was introduced by OBE (Item 40)

Responses	Totally disagree	Do not agree	Agree	Agree completely	Total
Frequency	28	31	9	2	**70****
Percentage	40.00	44.29	12.86	2.86	**100**

* Missing responses = 2

The largest majority of the participants "disagreed and totally disagreed" with the statement that assessment is a new concept that was introduced by OBE.

Table 9.28 Teaching, learning, and assessment are seen as separate processes within the OBE framework (Item 41)

Responses	Totally disagree	Do not agree	Agree	Agree completely	Total
Frequency	28	35	7	0	**70****
Percentage	40.00	50.00	10.00	0.00	**100**

*Missing responses = 2

According to Table 9.27, 90% of the participants "disagreed and totally disagreed" with the statement that teaching, learning and assessment are seen as separate processes within the OBE framework.

Table 9.29 Critical and developmental outcomes should be contextualized within the framework of learning outcomes and assessment standards (Item 42)

Responses	Totally disagree	Do not agree	Agree	Agree completely	Total
Frequency	1	1	52	17	**71***
Percentage	1.41	1.41	73.24	23.94	**100**

*Missing responses = 1

Table 9.29 indicates that 97.18% of the participants "agreed and completely agreed" that critical and developmental outcomes should be contextualised within the framework of learning outcomes and assessment standards.

Table 9.30 Departing from OBE approach, learners should be aware of assessment criteria before any assessment activity can take place (Item 43)

Responses	Totally disagree	Do not agree	Agree	Agree completely	Total
Frequency	0	3	43	24	**70****
Percentage	0.00	4.29	61.43	34.29	**100**

*Missing responses = 2

The largest majority of the participants "agreed and completely agreed" that, departing from an OBE approach, learners should be aware of assessment criteria before any assessment activity can take place.

Synthesis

Based on the participants' responses to statements on OBA departing from an OBE perspective, the following can be deducted:

- Most of the participants are of the opinion that assessment is primarily the teacher's task.
- The largest majority of the participants do not perceive assessment as a "new" OBE concept.
- Nine out of ten of the participants do not view teaching, learning and assessment as separate processes within an OBE framework.

- With the exception of two participants, all the others are in agreement that critical and development outcomes should be contextualised within the framework of Learning Outcomes and Assessment Standards.
- The participants are almost unanimous that learners should be aware of assessment criteria before any assessment activity can take place.

9.3.4 Participants' responses to assessment of Physical Sciences in the FET Band

In this section, participants' responses to items on the assessment of Physical Sciences in the FET Band are presented in Tables 9.31 to 9.36.

Table 9.31 To what extent are your assessment activities designed to provide learners with the opportunity to acquire and develop the following skills/abilities? (Items 44 – 46)

Skills/abilities		**To no extent**	**To a small extent**	**To a considerable extent**	**To a large extent**	**Total**
Practical, scientific and problem solving skills	**Frequency**	0	10	48	13	**71***
	Percentage	0.00	14.08	67.61	18.31	**100**
The ability to construct and apply scientific knowledge	**Frequency**	0	8	43	20	**71***
	Percentage	0.00	11.27	60.56	28.17	**100**
The ability to identify and critically evaluate the contested nature of science and its relationships to technology.	**Frequency**	1	12	40	18	**71***
	Percentage	1.41	16.90	56.34	25.35	**100**

*Missing responses = 1

- The largest majority of the participants (85.29%) indicated that their assessment activities are "to a considerable extent and large extent" designed to provide learners with the opportunity to acquire practical, scientific and problem solving skills.

- More than eighty percent of the participants (88.73%) also indicated that their assessment activities are "to a considerable and a large extent" designed to provide learners with the opportunity to acquire and develop their abilities to construct and apply scientific knowledge.

- The largest majority of the participants' (81.69%) responded that their assessment activities are "to a considerable and large extent" designed to provide learners with the opportunity to acquire and develop the ability to identify and critically evaluate the contested nature of science and its relationships with technology, society and the environment.

Synthesis

From the above it is clear that most participants design their assessment activities to develop learners' practical, scientific and problem solving skills, their ability to construct and apply scientific knowledge, and their ability to identify and critically evaluate the contested nature of science and its relationship with technology, society and the environment.

Table 9.32 Aims of participants' assessment activities (Items 47 – 51)

To: ……………..		**To no extent**	**To a small extent**	**To a considerable extent**	**To a large extent**	**Total**
Develop learners' knowledge, skills and values	**Frequency**	0	7	29	35	**71***
	Percentage	0.00	9.86	40.85	49.30	**100**
Assess learners' strengths and weaknesses	**Frequency**	0	5	37	29	**71***
	Percentage	0.00	7.04	52.11	40.85	**100**
Provide additional support to learners	**Frequency**	2	6	37	26	**71***
	Percentage	2.28	8.45	52.11	36.62	**100**
Revisit or revise certain sections of the curriculum	**Frequency**	1	4	32	33	**71***
	Percentage	1.43	5.71	45.71	47.14	**100**
Motivate and encourage learners	**Frequency**	0	4	24	43	**71***
	Percentage	0.00	5.63	33.80	60.56	**100**

*Missing responses = 1

According to Table 9.32

- The largest majority (90.15%) of the participants indicated that their assessment activities are "to a considerable and large extent" aimed at developing learners' knowledge, skills and values.
- Over ninety percent of the participants (92.85%) indicated that their assessment activities are "to a considerable and large extent" aimed at assessing learners' strengths and weaknesses.
- Almost ninety percent of the participants (88.73%) indicated that their assessment activities are "to a considerable and large extent" aimed at providing additional support to learners.
- The largest majority of the participants (92.85%) responded that "to a considerable and large extent" their assessment aims to revisit or revise certain sections of the curriculum.
- Almost ninety-five percent of the participants (94.36%) responded that "to a considerable and large extent" their assessment activities aim to motivate and encourage learners.

Synthesis

From the above it is clear that the majority of the participants designed their assessment activities with the aim to:

- develop learners' knowledge, skills and values
- assess learners' strengths and weaknesses
- provide additional support for learners
- revisit or revise certain sections of the curriculum, and
- to motivate and encourage learners.

Table 9.33 To what extent do you consider the following principles of high quality assessment when you plan assessment tasks? (Items 52 – 54)

Principle of high quality assessment		To no extent	To a small extent	To a considerable extent	To a large extent	Total
Reliability	**Frequency**	1	5	37	27	**70****
	Percentage	1.43	7.14	52.86	38.57	**100**
Validity	**Frequency**	1	3	36	31	**71***
	Percentage	1.41	4.23	50.70	43.66	**1000**
Authenticity	**Frequency**	1	4	32	34	**71***
	Percentage	1.41	5.63	45.07	47.89	**100**

*Missing response = 1

**Missing responses = 2

From the previous table it is clear that over 90% of the participants consider reliability, validity and authenticity “to a considerable and large extent” when they plan assessment tasks.

Synthesis

From the above it is clear that the majority of the participants consider the principles of high quality of assessment when they plan their assessment tasks.

Table 9.34 Strategies that contribute towards the effective assessment of Physical Sciences in the FET Band (Items 55 – 68)

Are ……		**To no extent**	**To a small extent**	**To a considerable extent**	**To a large extent**	**Total**
Projects	**Frequency**	1	15	32	21	**71***
	Percentage	1.43	21.43	45.71	30.00	**100**
Presentations	**Frequency**	5	15	33	17	**70****
	Percentage	7.14	21.43	47.14	24.29	**100**
Debates	**Frequency**	11	19	29	9	**68******
	Percentage	16.18	27.94	42.65	13.24	**100**
Simulations	**Frequency**	8	8	38	13	**67*******
	Percentage	11.94	11.94	56.72	19.40	**100**
Assignments	**Frequency**	1	11	32	26	**70****
	Percentage	1.43	15.71	45.71	37.14	**100**
Case studies	**Frequency**	5	14	30	19	**68******
	Percentage	7.35	20.59	44.12	27.94	**100**
Essays	**Frequency**	15	18	25	9	**67*******
	Percentage	22.39	26.87	37.31	13.43	**100**
Practical tasks	**Frequency**	0	2	29	38	**69*****
	Percentage	0.00	2.90	42.03	55.07	**100**
Performances	**Frequency**	8	13	31	15	**67*******
	Percentage	11.94	19.40	46.27	22.39	**100**
Exhibitions	**Frequency**	7	19	26	17	**69*****
	Percentage	10.14	27.54	37.68	24.64	**100**
Research projects	**Frequency**	0	6	33	30	**69*****
	Percentage	0.00	8.70	47.83	43.48	**100**
Tests	**Frequency**	0	1	26	43	**70****

	Percentage	0.00	1.43	37.14	61.43	**100**
Examinations	**Frequency**	0	0	21	49	**70****
	Percentage	0.00	0.00	30	70	**100**
Portfolios	**Frequency**	10	8	24	27	**69*****
	Percentage	14.49	11.59	34.78	39.13	**100**

*Missing response = 1

**Missing responses = 2

***Missing responses = 3

****Missing responses = 4

*****Missing responses = 5

- Most of the participants (75.71%) indicated that projects contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- 71.43% of the participants indicated that presentations contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- More than half of the participants (55.89%) indicated that debates contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- Most of the participants (76.12%) indicated that simulations contributed "to considerable and large extent" towards effective assessment of Physical Sciences in the FET Band.
- The largest majority of the participants (82.85%) indicated that assignments contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- Most of the participants (72.06%) indicated that case studies "to a considerable and large extent" contribute towards the effective assessment of Physical Sciences in the FET Band.
- Half of the participants (50.74%) indicated that essays contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- The largest majority of the participants (97.10%) indicated that practical work/tasks contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- Most of the participants (68.66%) indicated that performances contribute "to a considerable and a large extent" towards the effective assessment of Physical Sciences in the FET Band.
- More than half of the participants (62.32%) indicated that exhibitions contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.
- More than ninety percent of the participants (91.30%) indicated that research projects contribute "to a considerable and large extent" towards the effective assessment of Physical Sciences in the FET Band.

- Almost hundred percent of the participants (98.75%) indicated that tests contribute “to a considerable and large extent” towards the effective assessment of Physical Sciences in the FET Band.
- All the participants (100%) unanimously indicated that examinations contribute “to a considerable and large extent” towards the effective assessment of Physical Sciences in the FET Band.
- Most of the participants (73.91%) indicated that portfolios contribute “to a considerable and large extent” towards the effective assessment of Physical Sciences in the FET Band.

Synthesis

From the above it is clear that the majority of the participants found the following strategies to contribute “to a small and no extent” towards effective assessment of Physical Sciences in the FET Band:

- essays
- performances
- exhibitions.

Table 9.35 Continuous assessment (CASS) benefits that contribute towards the effective assessment of Physical Sciences in the FET Band (Items 69 – 78)

		To no extent	To a small extent	To a considerable extent	To a large extent	Total
It provides teacher with reliable information of learners’ progress because their learning is regularly assessed throughout the year.	**Frequency**	1	5	25	38	**69*** **
	Percentage	1.45	7.25	36.23	55.07	**100**
Learners set their own individual goals because they are involved in self-assessment.	**Frequency**	7	21	29	12	**69*** **
	Percentage	10.14	30.43	42.03	17.39	**100**
It furthers learners’ growth and development because they become active participants in the learning and assessment process.	**Frequency**	2	13	37	20	**72**
	Percentage	2.78	18.06	51.39	27.78	**100**

It provides feedback on the quality of learning and teaching.	**Frequency**	3	5	31	33	**72**
	Percentage	4.17	6.94	43.06	45.83	**100**
It allows for ways to give feedback to learners about what was achieved by the assessment activity.	**Frequency**	2	6	28	35	**71***
	Percentage	2.82	8.45	39.44	49.30	**100**
It allows for different assessment strategies.	**Frequency**	1	7	27	37	**72**
	Percentage	1.39	9.72	37.50	51.39	**100**
It provides for a variety of learner needs through utilization of assessment strategies.	**Frequency**	4	9	32	24	**69*****
	Percentage	5.80	13.04	46.38	34.78	
It promotes valid and reliable assessment.	**Frequency**	4	10	27	29	**70****
	Percentage	5.71	14.29	38.57	41.43	**100**
A more extensive section of the curriculum can be covered by means of CASS.	**Frequency**	10	9	29	24	**72**
	Percentage	13.89	12.50	40.28	33.33	**100**
Skills and concepts that are difficult to assess in examination/test situations can be assessed by means of CASS.	**Frequency**	6	7	32	27	**72**
	Percentage	8.33	9.72	44.44	37.50	**100**

*Missing response = 1

**Missing responses = 2

***Missing responses = 3

- The largest majority of the participants (91.30%) indicated that, “to a considerable and large extent”, continuous assessment (CASS) provides teachers with reliable information about learners’ progress because their learning is regularly assessed throughout the year.
- More than half of the participants (59.42%) indicated that, “to a considerable and large extent” CASS enables learners to set their own goals because they are involved in self-assessment.
- The majority of the participants (79.17%) indicated that, “to a considerable and large extent”, CASS furthers learners’ growth and development because they become active participants in the learning process.
- According to Table 9.20, the largest majority of the participants (88.89%) indicated that, “to a considerable and large extent”, CASS provides feedback on the quality of learning and teaching.

- The largest majority of the participants (88.74%) indicated that, “to a considerable and large extent”, CASS allows for ways of giving feedback to learners about what was achieved by the assessment activity.
- The largest majority of the participants (88.89) indicated that, “to a considerable and large extent”, CASS allows for different assessment strategies.
- The majority of the participants (81.16%) indicated that, “to a considerable and large extent”, CASS provides for a variety of learner needs through utilization of assessment strategies.
- Almost all the participants (80.00%) indicated that, “to a considerable and large extent”, CASS promotes valid and reliable assessment.
- Most of the participants (73.61%) indicated that, “to a considerable and large extent”, a more extensive section of the curriculum can be covered by means of CASS.
- Almost ninety percent of the participants (81.94%) indicated that “to a considerable and large extent” skills and concepts that are difficult to assess in examination/test situation can be assessed by means of CASS.

Synthesis

From the above it is clear that the largest majority of the participants agreed that the following Continuous Assessment (CASS) benefits contribute towards effective assessment of Physical Sciences in the FET Band:

CASS:

- provides teachers with reliable information regarding learners’ progress because their learning is regularly assessed throughout the year;
- enables learners to set their own goals because they are involved in self-assessment;
- furthers learners’ growth and development because they become active participants in the learning process;
- provides feedback on the quality of learning and teaching;
- allows for ways of giving feedback to learners about what was achieved by the assessment activity;
- provides for a variety of learner needs through utilization of assessment strategies;
- promotes valid and reliable assessment;
- makes it possible that a more extensive section of the curriculum can be covered by means of CASS;
- makes it possible that skills and concepts that are difficult to assess in examination/test situations can be assessed by means of CASS.

Table 9.36 Do you regard the OBA practice of assigning 25% to CASS and 75% to the summative assessment of Physical Sciences in the FET Band to be a fair practice? (Item 79)

Responses	Yes	No	Not sure	Total
Frequency	53	14	4	**71***
Percentage	74.65	19.72	5.63	**100**

*Missing response = 1

The majority of the participants (74.64%) indicated that they regard the OBA practice of assigning 25% to CASS and 75% to the summative assessment of Physical Sciences to be a fair practice.

9.3.5 Experiments and practical work

In this section, participants' responses to items on experiments and practical work are presented in Tables 9.37 to 9.39.

Table 9.37 How regularly do you instruct your learners to conduct experiments? (Item 80)

Responses	Not at all	1 every term	1 every two terms	Before/after a concept was taught	Total
Frequency	1	38	8	24	**71***
Percentage	1.41	53.52	11.27	33.80	**100**

*Missing response = 1

More than half of the participants (53.52%) indicated that they instruct their learners to conduct experiments only "once every term", while 33.80% indicated that they instruct their learners to conduct experiments either "before or after a concept was taught".

Table 9.38 Strategies to teach learners scientific inquiry skills during practical work? (Items 81 - 84)

Strategies to teach learners scientific inquiry skills		Not at all	To a small extent	To a considerable extent	To a large extent	Total
Demonstration	**Frequency**	0	13	33	26	**72**
	Percentage	0.0	18.06	45.83	36.11	**100**
Hands-on experiments (conducted by learners themselves)	**Frequency**	3	16	34	19	**72**
	Percentage	4.17	22.22	47.22	26.39	**100**
Simulations (of experiments)	**Frequency**	11	21	32	7	**71***
	Percentage	15.49	29.58	45.07	9.86	**100**
Multimedia presentations (e.g. DVD, Video experiments)	**Frequency**	27	22	16	7	**72**
	Percentage	37.50	30.56	22.22	9.72	**100**

*Missing response = 1

- According to Table 9.23, the largest majority of the participants (81.94%) indicated that “to a considerable and large extent” they use demonstration as one of their strategies to teach learners scientific inquiry skills during practical work.
- The majority of the participants (63.61%) indicated that “to a considerable and large extent” they use hands-on experiments (conducted by learners themselves) to teach learners scientific inquiry skills during practical work.
- Most of the participants (54.93%) indicated that “to a considerable and large extent” they use simulations to teach learners scientific inquiry skills during practical work.
- The majority of the participants (68.16%) indicated that “to a small and no extent” they use multimedia presentations to teach learners scientific inquiry skills during practical work.

Table 9.39 Problems/challenges prohibiting participants from using practical methods (e.g. experiments) when assessing learners in Physical Sciences? (Items 85 – 91)

Problems/challenges		Not at all	To a small extent	To a considerable extent	To a large extent	Total
My lack of training in practical work.	**Frequency**	35	27	7	2	**71***
	Percentage	49.30	38.03	9.86	2.82	**100**
The lack of resources at my school.	**Frequency**	12	34	8	17	**71***
	Percentage	16.90	47.89	11.27	23.94	**100**
My inability to design assessment instrument that assesses learner performance at different cognitive levels across all the Learning Outcomes.	**Frequency**	32	23	11	4	**70****
	Percentage	45.71	32.86	15.71	5.71	**100**
My fear of causing accidents when practical work is conducted.	**Frequency**	49	13	4	3	**69*****
	Percentage	71.01	18.84	5.80	4.35	**100**
Insufficient time for doing practical work.	**Frequency**	16	24	14	15	**69*****
	Percentage	23.19	34.78	20.29	21.74	**100**
Lack of knowledge of practical aspects and scientific inquiry.	**Frequency**	42	22	4	2	**70****
	Percentage	60.00	31.43	5.71	2.86	**100**
Lack of Departmental support (workshops, visits)	**Frequency**	31	15	10	8	**64**********
	Percentage	48.44	23.44	15.63	12.50	**100**

*Missing response = 1

**Missing responses = 2

***Missing responses = 3

********Missing responses = 8

- According to Table 9.39 above, the largest majority of the participants (87.33%) indicated that they are “not at all and to a small extent” prohibited by a lack of training in practical work when they want to conduct experiments and demonstration, whereas 49.30% reported that they do feel prohibited.

- Most of the participants (64.79%) indicated that they are "not at all and to a small extent" prohibited by lack of resources at schools when it comes to using practical work methods (e.g. experiments) to assess their learners in Physical Sciences.
- The largest majority of the participants (78.57%) indicated that they are "not at all and to a small extent" prohibited by their inability to design assessment instruments that assess learner performance at different cognitive levels across all the Learning Outcomes when they use practical methods (e.g. experiments) to assess their learners in Physical Sciences.
- The largest majority of the participants (89.85%) indicated that they are "not at all and to a small extent" prohibited by a fear of causing accidents when practical work is done when they want to use practical methods (e.g. experiments) to assess their learners in Physical Sciences.
- Most of participants (76.89%) indicated that they are "not at all and to a small extent" prohibited by insufficient time when it comes to doing practical work in order to assess their learners in Physical Sciences.
- Almost all the participants (93.43%) indicated that they are "not all and to a small extent) prohibited by a lack of knowledge of practical aspects and scientific inquiry from using practical methods (e.g. experiments) when they want to assess their learners in Practical Sciences.
- The majority of the participants (71.88%) indicated that they are "not at all and to a small extent" prohibited by a lack of Departmental support (e.g. workshops) from using practical methods (e.g. experiments) to assess their learners in Physical Sciences.

Synthesis

Based on the participants' responses, it can be concluded that the majority of the participants are not prohibited by the following problems or challenges from using practical methods (e.g. experiments) when assessing learners in Physical Sciences:

- A lack of training in practical work;
- a lack of resources at school;
- their inability to design assessment instrument that assess learner performance at different cognitive level across all the Learning Outcomes;
- a fear of causing accidents when practical work is conducted;
- insufficient time for conducting practical work;
- a lack of knowledge of practical aspects and scientific inquiry;
- a lack of departmental support.

9.4 SUMMARY OF THE RESULTS EMANATING FROM THE STRUCTURED (CLOSED) ITEMS IN SECTION B OF THE QUESTIONNAIRE

On the basis of the participants' responses to the structured items of Section B of the questionnaire, the following became apparent:

- Most participants received OBE training, but the duration of their training was relatively short.
- The Department of Education presented most of the training.
- In general, the quality of the training seemed to be satisfactory and most of the participants indicated that they were confident to implement OBA.
- Most of the participants are familiar with the different NCS documents and most of the NCS documents are available to all the teachers in their schools.
- Most of the participants have a personal copy of all these documents in their possession and find these documents easy to understand.
- Most of the participants are of the opinion that the documents contained clear guidelines for implementation.
- Most participants demonstrate their understanding of the NCS documents by indicating that they:
  - do not see teaching, learning and assessment as separate processes;
  - agree that critical and developmental outcomes should be contextualised within the framework of learning outcomes and assessment standards;
  - agree that learners should be aware of assessment criteria before any assessment activity can take place.
- Most participants design their assessment activities to develop learners':
  - practical, scientific and problem solving skills;
  - ability to construct and apply scientific knowledge;
  - ability to identify and critically evaluate the contested nature of science and its relationships with technology, society and the environment.
- The majority of the participants design their assessment activities with the aim to:
  - develop learners' knowledge, skills and values;
  - assess learners' strengths and weaknesses;
  - provide additional support to learners;
  - revisit or revise certain sections of the curriculum, and
  - motivate and encourage learners.
- Most participants consider the principles of high quality of assessment when they plan their assessment activities.
- The majority of the participants find essays, performances and exhibitions to contribute "to a small and no extent" towards effective assessment of Physical Sciences in the FET Band.

- Most participants agreed that CASS contributes towards effective assessment of Physical Sciences in the FET Band because it:
    - provides teachers with relevant information of learners' progress;
    - enables learners to set their own goals;
    - furthered learners' growth and development;
    - provides feedback on the quality of learning and teaching;
    - allows for ways of giving feedback to learners about what was achieved by the assessment activity;
    - provides for a variety of learners needs through utilization of different assessment strategies;
    - promotes valid and reliable assessment;
    - makes it possible that a more extensive section of the curriculum can be covered;
    - makes it possible that skills and concepts that are difficult to assess in examination/test situation can be assessed by means of other CASS strategies.
- The majority of the participants find the OBA practice of assigning 25% to CASS and 75% to the summative assessment of Physical Sciences to be a fair practice.
- Most participants instruct their learners to conduct experiments only "once every term".
- The majority of the participants use demonstration as their major strategy to teach learners scientific inquiry skills during practical work.
- The majority of the participants are not prohibited by any of the following problems or challenges when they want to use practical work methods (e.g. experiments) to assess learners in Physical Sciences:
    - a lack of training in practical work;
    - a lack of resources at school;
    - their inability to design assessment instruments that assess learner performance at different cognitive level across the Learning Outcomes;
    - a fear of causing accidents when practical work is conducted;
    - insufficient time for doing practical work;
    - a lack of knowledge of practical aspects and scientific inquiry;
    - a lack of departmental support.

9.5 DISCUSSION OF THE PARTICIPANTS' RESPONSES TO THE STRUCTURED (CLOSED) ITEMS IN SECTION B OF THE QUESTIONNAIRE

The participants' responses indicate that the majority (80.56%) of the participants received training in the implementation of the OBA. A small number of participants (19.44%) did not receive training at all (See Table 9.17). However, they are still expected to successfully implement the curriculum. The training received by 38.96% of the participants lasted for a week or more (See Table 9.18). It is alarming that

44.45% of the participants were expected to successfully implement the curriculum after having been trained for a period of less than a week (i.e. few hours to more than 2 days).

The training received by most of the participants was presented by the Department of Education (91.94%), with only 8.06% having received the training in OBA of Physical Sciences from other institutions (See Table 9.19). Ten of the participants who reported that they received training in OBA of Physical Sciences could not tell who presented the training. The minority of the participants (38.89%) rated the training in OBA they received to be "good" to "very good" (See Table 9.20). 80.28% (Table 9.21) of the participants indicated that they were "confident" to "very confident" to implement OBA. The lack of confidence to implement OBA felt by 19.73% of the participants can be blamed on a "poor" or "very poor" standard of training that lasted for less than one week or just a few hours. Those who rated the standard of training they received in OBA to be "poor" or "very poor", and those who reported a lack of confidence in implementing OBA, were given the opportunity in open ended questions to explain why they rated the standard of the training they received to be poor or very poor (paragraph 9.6.1), and why they think they lack confidence to implement OBA (paragraph 9.6.2).

Most participants (87.50% to 98.61%) are familiar with all the NCS documents, the NCS documents are available to teachers at almost all (85.92% to 97.22%) the participants' schools, and most participants indicated to personally be in possession of all the NCS documents (i.e. Learning programme guidelines, Subject statement, Subject assessment guidelines, assessment policy frame work, and examination guidelines) (refer to Table 9.22 to Table 9.24). It is shocking to find out that there are still some schools (2.82% to 8.45%) that are not in possession of the NCS documents even though its inception dates back to 2007 for the FET Band (Table 9.23). The respondents indicated that the NCS documents are easy to understand (90.28%), with only 6.94% of the participants who find the NCS document to be difficult to understand. Those who find the NCS document to be difficult to understand and to contain unclear guidelines for implementation were given the opportunity to state the reasons why they feel like this.

Although most participants indicated that the NCS documents are easy to understand. It is therefore surprising that 50% of the participants agreed that assessment is primarily the teacher's task and 16.18% were in complete agreement with the statement (Table 9.11). Some of the alternative methods of assessment indicated in the NCS (DoE, 2003b:58) include self-assessment, peer assessment and group assessment. For that reason, it is clear that assessment is not solely the teachers' responsibility, but that the teacher, the learner and the parents should all participate in assessment. It should be noted that involving learners in their own assessment does not mean that they are in command of decisions about what should be learned and tested; but rather indicates an involvement where learners learn how to use assessment information to obtain an honourable and self-critical reflection on their own work (Warnich; 2010:105).

As indicated in paragraph 5.1, assessment always has and still does represent an important cornerstone of education. It is critical in the South African National Curriculum Statement (NCS), especially for Grades 10 – 12 (DoE, 2003b:55). The NCS (DoE, 2003b:55) defines assessment to be a process of collecting and interpreting evidence in order to determine the learner's progress in learning and to make a judgement about learner's performance. Assessment has been in existence since the inception of formal education. This means that assessment has been there long before OBE started in South Africa. According to 15% of the participants, assessment is a new concept that was introduced by OBE. This might mean that prior to OBE, learners were simply not assessed.

Most participants (90%) indicated that they "do not agree" or "totally disagree" that teaching, learning and assessment are seen as separate processes within the OBE framework. Only 10% agreed with the statement. Two of the participants did not indicate their response to this item (item 41). Warnich (2008:303) explains that "all teaching and learning activities should be informed by the broad overarching critical and developmental outcomes and should contribute towards the attainment of these outcomes". Thus, critical and developmental outcomes should be contextualised within the framework of learning outcomes and assessment standards (DoE, 2003b:15). It is pleasing to realise that most participants (97.18%) indicated that they "agree" or "completely agree" with this item (item 42), while only two participants (2.82%) indicated that they "do not agree" or "totally disagree" that critical and developmental outcomes should be contextualised within the framework of learning outcomes and assessment standards.

Departing from an OBE approach (DoE, 2003b:57), learners should be aware of the assessment criteria before any assessment activity can take place. Most participants (95.72%) indicated that they "agree" or "agree completely" that learners should be aware of the assessment criteria before any assessment activity can take place for learners to have a sufficiently clear picture of the targets that their learning is meant to attain (Black & William, 2001:7) (as quoted by Reyneke, 2008:123). This indicates that most participants are indeed in possession of and/or are conversant in the NCS documents.

Furthermore, the NCS document (Subject statement) (DoE, 2003b:10) stresses that the subject Physical Sciences should prepare learners for future learning, specialist learning, employment, citizenship, holistic development, socio-economic development and environmental management by developing competencies in the three focus areas referred to as the scope of Physical Sciences: 1. practical, scientific and problem solving skills; 2. the ability to construct and apply scientific knowledge; 3. and the ability to identify and critically evaluate the contested nature of science and its relationships to technology. The items contained in Table 9.47 were aimed at getting an indication of the measure in which respondents' assessment activities are designed to provide learners with the opportunity to acquire and develop the above focus areas of Physical Sciences. In response to items 44 to 46, most participants (67.61%) indicated that their assessment activities are "to a considerable extent" designed to provide learners with the opportunity to develop practical, scientific and problem solving skills, with 18.31% indicating that their activities are “to a larger extent” designed to provide learners with such opportunities. Only 14.08% of the participants indicated that their activities are “to a small extent” designed to provide learners with the opportunity to develop the practical, scientific and problem solving skills. One wonders what exactly these participants’ teaching intends to achieve.

Item 43 referred to the skills or abilities as reflected in Learning Outcome 2 (DoE, 2005a:7); the ability to construct and apply scientific knowledge. The majority of the participants (60,56%) indicated that their assessment activities are “to a considerable extent” designed to provide learners with the opportunity to develop the ability to construct and apply scientific knowledge, while 28.17% answered “to a larger extent” to this item (item 45) (See Table 9.47). Eight of the participants (11.27%) indicated that their assessment activities are ‘to a small extent” designed to provide learners with such opportunities, something that continues to be a worrying factor.

Item 46 referred to Learning Outcome 3 (DoE, 2005a:7). More than half (56.34%) of the participants indicated that their assessment activities are “to a considerable extent” designed to provide learners with the opportunity to acquire and develop the ability to identify and critically evaluate the contested nature of science and its relationship to technology. 25.35% indicated that their activities are “to a larger extent” designed to meet this goal, and twelve of the participants indicated “to a small extent” to this item (item 46). One participant (1.41%) indicated that his/her assessment activities are ‘to no extent” designed to meet learning outcome 3. This implies that this participant’s assessments are not designed to contribute towards the effective OBA of Physical Sciences in the FET Band.

Most participants (56% to 67% and 18% 28%) design their activities “to a considerable” and “larger extent” to provide learners with the opportunity to acquire and develop practical, scientific and problem solving skills; the ability to construct and apply scientific knowledge; and the ability to identify and critically evaluate the contested nature of science and its relationships to technology (See Table 9.47). In essence, if participants’ activities are aimed at preparing the learners to realise the stated Physical Sciences Learning Outcomes, then, the activities are OBA as required by the NCS. Similarly, most participants responded positively to item 42 (See Table 9.29) (i.e. critical and developmental outcomes should be contextualised within the framework of Learning Outcomes and Assessment Standards) because their activities are designed to acquire and develop the LOs and in such a way that the Critical and Developmental Outcomes are contextualised within the framework of LOs and Ass. Therefore, one can conclude that most participants are capable of designing all teaching, learning and assessment activities from what learners should know, do and produce by the end of Grade 12 (design-down).

The successful implementation of OBA is influenced mainly by teachers’ knowledge and comprehension regarding the mutual cohesion and interaction of the various design structures of the NCS. Thus, meaningful OBA practices depend on the ability of the teacher to integrate critical outcomes, developmental outcomes, learning outcomes, lesson outcomes and assessment standards meaningfully when facilitating the learning area or subject content (Warnich, 2010:93). For effective implementation of OBA, every participant should be conversant in it, and also know that the LOs describe the knowledge, skills, attitudes and values that learners are supposed to demonstrate at the end of a specific Band. A learner's attainment of LOs depends on the learner's attainment of the Assessment Standards. Assessment Standards embody the skills, knowledge, attitudes and values that are required to reach LOs and to show progression in the development of concepts, knowledge, skills and processes from grade to grade (DoE, 2002:14 and Warnich, 2010:93). All this expertise should be continuously put into practice through CASS, which serves multiple purposes of assessment.

Beside ensuring validity and reliability within the NCS (DoE, 2003b:57), CASS, through informal daily assessment and the formal Programme of Assessment is used to (DoE, 2005a:1): develop learners' skills, knowledge, attitudes and values (SKAV); assess learners' strengths and weaknesses; provide additional support to learners; revisit or revise certain sections of the curriculum and motivate learners. The Assessment Guidelines for Physical Sciences further indicates that assessment in the NCS is an integral part of teaching and learning, thus, assessment should be part of every lesson and (DoE, 2005:1) teachers should plan a formal year-long Programme of Assessment that will enable them to inculcate SKAV in learners. The items contained in Table 9.48 were designed specifically to explore participants' experiences in this regard.

When responding to these items (items contained in Table 9.48), there were participants who still indicated that their assessment activities are "to a small extent" (9.86%) and "to a considerable extent" (40.85%) aimed at developing learners' skills, knowledge, attitudes and values. This occurred even though participants indicated that they received training in the implementation of OBE (item 18), and also indicated that they were confident (item 21) to implement OBA. It is also despite the fact that the NCS documents require that (DoE, 2002:13 and 2003a:10) all teaching and learning should develop learners' knowledge, skills and attitudes. Moreover, more than half (52.11%) of the participants further indicated that their assessment activities are "to a considerable extent" aimed at assessing learners' strengths and weaknesses. It is pleasing to learn that twenty nine (40.85%) of the participants indicated that their assessment activities are "to a large extent" designed to assess learners' strengths and weaknesses, with the minority (7.04%) indicating that their assessment activities are "to a small extent" aimed at assessing learners' strengths and weaknesses.

Most participants (52.11%) indicated that their assessment activities are "to a considerable extent" aimed at providing additional support to learners. This is something that the NCS document emphasises (DoE, 2005a:1) and that is stressed by 36.62% of the participants when they indicated that their assessment activities are “to a large extent” aimed at developing additional support to learners. This indicates that most participants’ assessment activities are learner-oriented.

The learner-oriented assessment seems to be in place since an almost equal number of participants (47.74% and 45.71% respectively) indicated that their assessment activities are “to a larger extent” and “to a considerable extent” aimed at revisiting or revising certain sections of the curriculum. The majority of the participants (60.56%) indicated that their assessments activities are “to a large extent” aimed at motivating and encouraging learners. This response shows that participants’ assessment tasks also aimed to enhance the learners’ motivation.

Beside been learner-oriented, assessment should be an integral part of teaching and learning and should be part of every lesson, and should, amongst others, always be valid, reliable and authentic (refer to Paragraph 6.2.7).

The above is supported by the majority of the participants in their responses to the items contained in Table 9.49. These items were formulated to enquire from the participants to what extent they consider the principles of high quality assessment (i.e. reliability (paragraph 5.5), validity (paragraph 5.4) and authenticity (paragraph 5.3)) when they plan their assessment tasks (DoE, 2003b:57). The majority of the participants indicated that they consider reliability, validity and authenticity “to a considerable extent” and “to a large extent” when planning the assessment tasks. Thus, most participants adhere to the NCS document (DoE, 2003b:57) by considering the principles of high quality assessment.

It is impossible for each assessment task to be totally valid or reliable by itself (refer to Paragraph 5.2). For that reason, the NCS (DoE, 2003b:57) purports that learners’ progress be based on more than one assessment activity. That’s the principle behind continuous assessment (CASS). It (CASS) involves assessment activities that are spread throughout the year, using various kinds of assessment instruments and methods or strategies (DoE, 2003b:57 and DoE, 2005a:8-9). Table 9.50 indicates participants’ responses to the extent to which their assessment strategies contribute towards the effective assessment of Physical Sciences in the FET Band. NCS documents (DoE, 2003b:57 and DoE, 2005a:8-10) listed tests, examinations, projects and assignments, practical investigations and experiments, projects, and research tasks as the main assessment strategies of the curriculum. Tests and examinations are (DoE, 2003b:59) regarded as an important part of the curriculum because they give good evidence of what has been learned.

This is supported by some of the participants’ responses to items contained in Table 9.50. Most participants indicated that projects contribute “to a considerable extent” and “to a large extent” towards the effective assessment of Physical Sciences in the FET Band.

Although NCS documents (DoE, 2003b:57 and DoE 2005a:8-10) indicate that different assessment activities may be used, presentations, debates, simulations, case studies, essays, performances and exhibitions did not seem to be assessment strategies or techniques that were popular in Physical Sciences FET Band (see participants responses in Table 9.50).

The majority of participants' responses indicated that assignments contribute "to a considerable extent' and "to a large extent" towards the effective assessment of Physical Sciences in the FET Band. This makes the assignment one of the more popular assessment strategies in Physical Sciences.

Practical tasks/investigations or experiments are the most important aspect of assessment in Physical Sciences in the FET Band. They assess all the LOs with the focus on the practical aspects and the process skills required for scientific inquiry and problem solving (DoE, 2005a:10). Thus, assessment activities should be designed (DoE, 2005a:10) so that learners are assessed on their use of scientific inquiry skills like planning, observing and gathering information, comprehending, synthesising, generalising, hypothesising and communicating results and conclusions. Due to its overarching importance in Physical Sciences, the majority of the participants indicated that practical tasks "to a large extent" and "to a considerable extent contribute towards the effective assessment of Physical Sciences in the FET Band. Two participants (2.90%) who indicated that practical activities do "to a small extent" contribute towards the effective assessment of Physical Sciences may not have the science apparatus (item 14 and 86) or training in practical work (item 85). Thus, practical investigations or experiments are also popular assessment strategies in Physical Sciences.

Research projects/tasks involves the collection of data and/or information to solve a problem or to understand a particular set of circumstances and/or phenomena. They allow learners to demonstrate outcomes in different ways like drawing or writing, observing and communicating one's findings. They assess improved understanding of social issues, improved attitude towards science learning, modest gains in thinking such as application of formal science to everyday events, critical thinking and decision making, as well as improved social responsibly actions (Stears & Gopal, 2008:594), thus, contributing towards effective assessment of Physical Sciences in the FET Band. Almost all the participants (91.32%) found research contributing "to a considerable" and "large extent" towards effective assessment of Physical Sciences in the FET Band.

Control tests and examinations are written under controlled conditions within a specified period of time. The student needs no extra material, only pen and paper. The advantage of these strategies is that they assess performance at different cognitive levels across all the learning outcomes with a greater focus on Learning Outcome 2 (DoE, 2005a:9). Most participants prefer this (table 9.19). These methods/strategies of assessment has a short-term focus and is aimed at the realisation of the full potential of the learner, for example, little attention is paid to the development of critical thought (Warnich & Wolhuter, 2010:75). Most of the participants (61.43%) indicated that tests “to a large extent” and “to a considerable extent” contribute towards the effective assessment of Physical Sciences in the FET Band, making tests and examination the most popular assessment strategies in Physical Sciences in the FET Band.

Literature (Warnich & Wolhuter, 2010:75) indicates that most teachers resort to tests and examinations (formal strategies) in the name of accountability, and to scrupulously comply with the administrative requirements of OBA. This type of attitude negates the principle on which assessment is based. In such cases the collection and recording of assessment data are reduced to a technical act to satisfy school management and the Department of Education (Warnich & Wolhuter, 2010:75; Beets, 2007:246; and Vandeyar & Killen, 2003:133). It is disappointing to find that after participants have attended training in OBA of Physical Sciences in the FET Band and were in possession of the NCS documents, some participant/s were still ignorant of the importance of the utilisation of different assessment strategies in the OBA of Physical Sciences in the FET Band.

Although there are other examinations that contribute towards the learner’s participation mark (i.e. midyear examinations and trial examinations), the year-end/final examination is regarded z the most important examination as it comprises 75% of the final mark (DoE, 2005a:12-13). Given the OBE’s stance on assessment, most of the participants (70%) indicated that examinations do “to a large extent” and “to a considerable extent” contribute towards effective assessment of Physical Sciences in the FET Band. 30% of respondents indicated that examinations contribute towards effective assessment of Physical Sciences in the FET Band. Participants’ preference for these (tests and examinations) traditional ways of assessment must be ascribed to the fact that they were trained to assess this way and they find it reliable (Reyneke, 2008:123). This makes examinations one of the most popular assessment strategies in Physical Sciences.

For the learner to be promoted to the next class, evidence of performance is required. For that reason, the programme of assessment should be recorded in the teacher’s portfolio of assessment. The learner should also maintain a portfolio of the assessment tasks that make up the programme of assessment. All the evidence should be kept for moderation purposes (DoE, 2005a:5). Although the importance of keeping a portfolio is explained, it is surprising to find that only 39.13% of the participants indicated that portfolios contribute “to a large extent” and 34.78% “to a considerable extent” towards effective assessment of Physical Sciences in the FET Band. This indicates that portfolios are not regarded as one of the most popular assessment strategies in Physical Sciences.

It was clear from the participants’ responses to the items contained in Table 9.50 that, despite the availability of a variety of assessment methods and techniques, there were some participants who displayed a particular preference for some assessment methods or strategies rather than others. One may ask whether this can be ascribed to their belief that some assessment methods are intrinsically better than others, or that they lack insight into the NCS or do not possess the necessary knowledge or skills of other assessment methods or strategies?

Table 9.51 provides information about the benefits of CASS towards the effective assessment of Physical Sciences in the FET Band (i.e. quality of assessment). The items in this table sought to find out from participants the extent to which they valued CASS. According to the information in Table 9.20, most of the participants indicated that CASS do "to a large extent" (55.07%) and "to a considerable extent" (36.23%) contribute towards the effective assessment of Physical Sciences in the FET Band as it provides teacher with reliable information of learners' progress because their learning is regularly assessed throughout the year. This support the NCS document that states that "teachers' assessment of learners' performances must have a greater degree of reliability", meaning that teachers' judgement of learners' competency should be generalisable across different times, assessment items and markers (DoE, 2003b:57).

Self-assessment enables learners to know what is expected of them (paragraph 6.4.1 and DoE, 2003b:58), making it easier for them to set their own individual goals. This statement is supported by 17.39% and 42.03% of the participants who respectively indicated that CASS do "to a large extent" and "to a considerable extent" contribute towards the effective assessment of Physical Sciences in the FET Band.

CASS furthers learners' growth and development because they become active participants in the learning and assessment process (DoE, 2003a:57). The majority of the participants (51.69% and 27.78% respectively) supported the statement that CASS do "to a considerable extent" and "to a large extent" further learners' growth and development because they become active participants in the learning and assessment process. This in turn contributes towards effective assessment of Physical Sciences in the FET Band.

According to participants' responses to item 71 in Table 9.35, the majority of the participants (45.83% and 43.06% respectively) indicated that CASS do "to a large extent" and "to a considerable extent" contribute towards effective assessment of Physical Sciences in the FET Band by providing feedback on the quality of learning and teaching. It is important for teachers to continuously keep up the quality of teaching and learning in OBE.

CASS allows for ways of giving feedback to learners about what was achieved by assessment activities and it enables learners to reflect on their own progress towards instructional objectives, to determine the learning strategies that are effective to them, and develop plans for their future learning (DoE, 2003b:57). This sentiment is supported by the majority of the participants. Respectively 49.30% and 39.44% of the participants stated that CASS contributes towards the effective assessment of Physical Sciences in the

FET Band by allowing for ways of giving feedback to learners about what was achieved by the assessment activity. This enables learners to participate actively in CASS.

The NCS document (DoE, 2003b:57) lists a number of assessment activities that can be employed for effective assessment of Physical Sciences in the FET Band. It further states that, “no assessment activity can be reliable by itself”, for that reason, learners must be assessed using different assessment strategies (DoE, 2003b:57). When responding to this item, the majority of the participants (51.39% and 37.50% respectively) agreed that CASS “to a large extent” and “to a considerable extent” contributes towards effective assessment of Physical Sciences in the FET Band by allowing for different assessment strategies. Therefore, most teachers use different assessment strategies and methods to assess their learners in Physical Sciences.

According to Table 9.35, most participants (46.38% and 34.78% respectively) respectively indicated that CASS “to a considerable extent” and “to a large extent” contributes towards effective assessment of Physical Sciences in the FET Band through the utilisation of different assessment strategies. Most participants supported the use of different assessment strategies.

According to the NCS CASS promotes valid and reliable assessment through utilisation of different assessment strategies (DoE, 2003b:57). When responding to this item (item 76) (See Table 9.51), most of the participants (41.43% and 38.57%) indicated that CASS “to a large extent” and “to a considerable extent” contributes towards effective assessment of Physical Sciences in the FET Band by promoting valid and reliable assessment. This indicates that the majority of the participants considered a high quality of assessment when they assess their learners in Physical Sciences.

Most participants (40.28% and 33.33% respectively) indicated that, “to a considerable extent” and “to a large extent”, a more extensive section of the curriculum is covered by means of CASS, thus contributing towards effective assessment of Physical Sciences in the FET Band. This shows that CASS not only promotes effective assessment of Physical Sciences, but also supports effective learning and teaching.

According to the NCS, CASS should be applied to sections of the curriculum that are best assessed using written tests and assignments and to sections that are best assessed through other assessment methods, such as performances, using practical or spoken evidence of learning (DoE, 2003b:57). Research shows that very few science teachers assess outcomes such as self-confidence, social skills or language as they are not regarded as science outcomes (Malcolm, 2005; and Stears & Gopal, 2008:594). Consequently, assessment strategies that assess such outcomes are rarely used (Table 9.19 and Stears & Gopal, 2008:594). This is also confirmed by participants’ responses to item 78 (See Table 9.35), which enquired whether skills and concepts that are difficult to assess in examination/test situations can be assessed by means of CASS? The majority of the participants (37.50% and 44.44%) indicated that CASS does “to a large extent" and "to a considerable extent contribute towards effective assessment of Physical Sciences in the FET Band through alternative assessment strategies that allow learners to demonstrate outcomes that are normally not assessed by tests, examinations and assignments.

It is clear from the responses of a few participants that they did not understand the principle of high quality assessment. The question may be asked again if these participants had been given enough information and practical training on the importance of meeting the principle of high quality assessment in any assessment situation in education. Maybe the assumption is true that: "Where and when participants are unsure, frustrated or incompetent to comply with the varying assessment strategies of OBA, they fall back into the traditional ways of a primarily norm-referenced, summative assessment" (Tables 9.19 & 9.20). It is advisable for participants to be aware of certain principles that should be followed to ensure the quality and credibility of their assessment practices. According to Warnich (2010:119), the OBA will only help to minimise the concerns and fears of learners, parents, educational institutions and the general public if it satisfies a set of principles that has been agreed upon (i.e. transparency, validity, reliability, fairness, feasibility and others).

For a learner to be promoted to the next phase in the FET Band, the learner has to achieve the LOs and ASSs. In Grades 10 and 11 all assessment of the National Curriculum Statement is internal. In Grade 12, the formal programme of assessment, which counts 25% is internally set and marked and externally moderated. The remaining 75% of the final mark for the certification in Grade 12 is externally set, marked and moderated (DoE, 2005b:1). The majority of the participants (74.65%) regarded the practice to be fair (See Table 9.36). It should be borne in mind that the practice can only be fair if it satisfies a set of principles that has been agreed upon by Department of Education and SAQA (South African Qualification Authority).

According to NCS, practical investigation (DoE, 2005b:10) should assess all Learning Outcomes, with the focus on the practical aspects and the process skills required for scientific inquiry and problem solving. Assessment activities should, according to the Department of Education (DoE, 2005b:10), be designed so that learners are assessed on their scientific inquiry skills like planning, observing and gathering information, comprehending, synthesising, generalising hypothesising and communicating results and a conclusion. It should furthermore assess performance at different cognitive levels across all the Learning Outcomes, with greater focus on LO 1, which weighs 30% of the paper 1 and paper 2 weighting of the Learning Outcomes. This can only be achieved if schools are provided with science apparatus and teachers are equipped with different effective science teaching and assessment strategies.

In order to find out what participants' experiences are with regard to practical work in Physical Sciences, items 80 – 91 were formulated as they are contained in Tables 9.37 to 9.39. According to the annual assessment plan for Grade 12 as suggested by the Department of Education (DoE, 2005b:13), at least one practical investigation task should be assessed during the first and the second terms. According to the responses to item 80 (See Table 9.37), all the participants but one instructed their learners to conduct experiments in accordance with the Subject Assessment Guidelines (Physical Sciences). Those who did not instruct their learners to do practical investigations were asked to give reasons for not doing so in an open-ended item (item 1B5).

According to Trowbridge et al. (2008:64), teaching science as inquiry means providing students with diverse opportunities to develop the abilities of scientific inquiry, while also learning the fundamental subjects of science. Inquiry is a multifaceted activity that involves making observations, posing questions, examining books and other resources of information to see what is an already known, planning investigation, reviewing what is already known in light of experimental evidence, using tools to gather, analyse and interpret data, and of proposing the results. Different strategies are used because of the diversity contained within the activity. These include amongst others demonstration (to provide learners with the opportunity to observe a phenomenon or event that they otherwise would not observe); hands-on experiments (providing learners with the opportunity to do experiments); simulations (presenting situations, concepts, and issues in a condensed and simplified form); and multimedia presentations (the use of a slide show, hypermedia, and video clips provide means for learners to put together in creative ways their ideas about a science concept). A number of researchers (Bouillon & Gomez, 2001; Moje, Collazo, Carrillo, & Marx, 2001; Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001) have shown that in highly resourced settings, inquiry instruction can be successful in urban classrooms when it includes materials that match with the culturally relevant knowledge and beliefs held by learners from different developmental backgrounds.

According to Table 9.38, most participants “to a considerable extent” and “to a large extent” use demonstration to teach learners scientific inquiry skills. Only 13 participants indicated that they use demonstration “to a small extent”.

Item 82 in Table 9.38 enquired as to what extent participants used hands-on experiments (practical investigation by learners) to teach science inquiry skills. Science inquiry skills imply that learners need to find solutions to real problems by asking and refining questions; designing and conducting investigations; gathering and analysing information and data; making interpretations, creating explanations, and drawing conclusions; and reporting findings (DoE, 2005a:8; Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tal, 2004:1064). Most participants (47.22% and 26.39%) respectively indicated that they “to a considerable extent” and “to a large extent” used hands-on experiments to teach learners scientific inquiry skills.

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work (Anderson, 2002:8). If learners are not exposed to similar practices, then their chances of understanding and conceptualising scientific concepts are doomed. As indicated above, scientific inquiry teaching does not imply that all teachers should pursue a single approach to teaching science, but rather to the activities of learners in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (Anderson, 2002:2-3). Participants who indicated that they "to no extent" use hands-on experiments to teach learners scientific inquiry skills were given the opportunity to motivate their responses in an open-ended item (item 2B5).

Simulation is also one of the strategies that teachers can use to increase learners' ability to apply concepts, analyse situations, solve problems, and understand different points of view (Trowbridge et al., 2008:31). In this strategy, teachers present situations, concepts, and issues in a condensed and simplified way using visual and auditory teaching and learning modes. It is mostly used to support interactive scientific inquiry. With careful design and inclusion of virtual inquiry tools, simulation-based curricula can successfully support real-world inquiry practices based on authentic interactivity with simulated worlds and tools, and can support inquiry that is equally compelling for learners (Nelson & Ketelhut, 2007:265). According to item 84 (See Table 3.38) more than half of the participants (45.05% and 9.86%) indicated that they "to a considerable extent" and "to a large extent" use simulations to teach learners scientific inquiry skills. This strategy is "to a small extent" and "not at all" used by respectively 29.58% and 15.49% of the participants. Such participants were given the opportunity to explain their situation in an open-ended item (item 2B5).

Multimedia presentations are of equal importance to enhance the scientific inquiry skills of learners. It is considered one of the most powerful applications of ICT to science at present. It animates and simulates real processes such as motion, photosynthesis, diffusion, or bonding atoms, and allows learners to execute "virtual experiments" that would be dangerous, costly, or otherwise not feasible in a school laboratory (Hennessy, Deaney & Ruthven, 2006:701-702). Table 9.38 indicates that the majority of the participants (30.56%, 22.22%, and 9.72%) use multimedia presentations "to a small extent"; "to a considerable extent"; and "to a large extent" respectively to teach learners scientific inquiry skills during practical work. 37.50% of the participants who indicated that they "not at all" use multimedia presentations to teach their learners scientific inquiry skills were given the opportunity to explain their response in an open-ended item (item 2B5).

Table 9.39 ask participants to indicate the extent to which certain challenges prohibit them from using practical methods when assessing learners in Physical Science. In order for participants to implement practical investigation in their classrooms, they must have a clear understanding of what it entails (refer to paragraph 6.4.6). The majority of the participants (49.30% and 38.03%) indicated that they are "not at all" and "to a small extent" prohibited by lack of training in practical work. Only a small number of the participants (9.86% and 2.82%) responded that "to a considerable extent' and "to a large extent" they are prohibited by lack of training. Participants who marked “to a considerable extent” and “to a large extent” to any of the items in Table 9.24 were given the opportunity to explain their response choice in an open-ended item (item 3B5).

Practical work as a vehicle to teach learners inquiry skills can be successfully applied in highly resourced settings (Marx et al., 2004:164). When responding to item 86 in Table 9.39, only 16.90% of the participants were “not at all” prohibited by a lack of resources from using practical investigation to assess their learners in Physical Sciences. It should be noted that the NCS (DoE, 2005a:13) demands from teachers to at least assess their learners by means of practical investigations once every first two terms of the year. Despite this instruction, teachers are sometimes not supplied with the necessary resources to do so, and this prohibits participants from using practical methods to assess their learners in Physical Sciences.

It is evident from item 87 that most (45.71% and 32.86%) of the participants were capable of designing assessment instruments that assess learner performance at different levels across all the LOs with ease. A worrying factor is that 15.71% and 5.71% of the respondents respectively indicated that they are “to a considerable extent” and “to a large extent” unable to design such instruments. These participants were given the opportunity to explain their response choice in an open-ended item (item 3B5).

Responses to item 6 of the participants’ biographical information indicated that most participants (60.27%) are well qualified in Physical Sciences. About 38% has a 1st or 2nd year qualification in Physical Sciences. Item 88 enquired whether participants’ fear of causing accidents when conducting practical work prohibits them from assessing learners by using practical methods. 71.01% of the participants indicated that fear of causing accidents is not a prohibiting factor when conducting practical work. This means that fear to conduct experiments was a prohibiting factor for about 30% of the participants. This response could be ascribed to a lack of training in conducting practical work.

The time allocation for Physical Sciences in the NCS is 38 weeks for teaching and assessment (DoE, 2005b:8). This time is allocated to teaching and assessment and is distributed based on the weight of the content, concepts and skills, and formal assessment per grade. The responses to item 89, reflected in Table 9.39, indicate that more than half (23.19% and 34.78%) of the participants responded that formal teaching and assessment time did not prohibit them from using practical work to assess their learners in Physical Sciences. Approximately 40% of the participants (20.29% and 21.74%) are “to a considerable extent” and “to a large extent” prohibited by insufficient time from using practical methods when they assess their learners in Physical Sciences.

When responding to item 90, contained in Table 9.39, most of the participants (60%) indicated that they are “not at all” prohibited by a lack of knowledge of practical aspects and scientific inquiry skills from using practical methods when assessing their learners in Physical Sciences. Teachers' understanding of science as inquiry and learning inquiry is fundamental to the task at hand (i.e. to equip learners with investigating skills relating to physical and chemical phenomena, and others) (DBE, 2011:6 and Anderson, 2002:8). The worrying factor is the 40% of the participants who were "to a small extent"; "to a considerable extent"; and "to a large extent" prohibited by a lack of knowledge in this regard.

Marx et al. (2004:1064) reveal that in highly resourced settings inquiry instruction in classrooms can be successful when it includes materials that leverage the culturally relevant knowledge and beliefs held by learners from diverse backgrounds. Nonetheless, although the educational potential for inquiry learning is remarkable, this learning cannot be achieved by merely placing learners in the midst of a complex scientific domain for free-reign investigation (Zion, Michalsky, & Mevarech, 2005:958). Learners need to be guided in small steps to the execution of certain inquiry demands by teachers. However, teachers cannot simply move to inquiry approaches to instruction from recitation and direct instruction. They need to learn many new ideas about learners, learning, curriculum, pedagogy, and assessment. Teachers need to be prepared to enact the curriculum appropriately for its underlying theoretical basis while adapting it to classroom circumstances (Fisherman, Marx, Best, & Tal, 2003) (as quoted by Marx et al., 2004:1066).

Item 91, contained in Table 9.39, enquired from participants the extent to which a lack of departmental support prohibits them from using practical work when assessing learners. Table 9.39 (Item 91) indicates that only 48.44% of the participants are "to no extent" prohibited by a lack of Departmental support. However, more than half (23.44%; 15.63% and 12.50%) of the participants are "to a smaller extent"; "to a considerable extent" and "to large extent" prohibited..

The failure to implement OBA in Physical Sciences cannot primarily be the participants' responsibility. OBE and OBA were only implemented in the FET Band in 2006, and the first cohort reached Grade 12 in 2008. One would expect the national and provincial Departments of Education to have systems in place to provide continuous support to teachers. The majority of these participants only attended training sessions of less than 5 days (Table 9.18), mostly presented by ill-equipped and ill-prepared facilitators who did not pay much attention to the practical implementation of the NCS (see items 1B1 and 2B1). This finding is supported by the research findings of Reyneke (2008:126). Teachers' inefficiency to implement OBA was also confirmed by Ms Naledi Pandor, the previous Minister of Education, at the end of September 2008 when she said that teachers struggle "to translate the curriculum into good classroom practices" and therefore "need support to implement the curriculum" (DoE, 2008 as quoted by Warnich & Wulhuter, 2010:71).

9.6 VALIDITY AND RELIABILITY OF SUB-SECTION B4 OF THE QUESTIONNAIRE

All the structured (closed) items under this sub-section (Sub-section B4) of the questionnaire deal with the effective assessment of Physical Sciences in the FET Band. It is divided into four (4) categories, namely: designing assessment activities; aims of effective OBA activities; principles of high quality assessment; and Outcomes-Based-Assessment strategies.

In order to determine the construct validity of this section (Sub-section B4) of the questionnaire, confirmatory factor analyses utilizing a principal axis factoring rotation method (Oblimin with Kaiser Normalization) were conducted. The results of these factor analyses are displayed in Tables 9.40.1 – 9.46.5. In order to determine the reliability of Sub-section B4 of the questionnaire, Cronbach's alpha coefficients were also calculated.

9.6.1 Factor analysis 1: Designing assessment activities (Items 44 – 46)

Table 9.40.1 provides information about the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity.

Table 9.40.1 Kaiser-Meyer-Oblimin Measure of Sampling Adequacy and Bartlett's test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.715
Bartlett's Test of Sphericity	Approx. Chi-Square	101.484
	Df	3
	Significance (p-value).	.000

Bartlett's test of sphericity resulted in a p-value smaller than .001, which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure is .715, which indicates that the sample size was adequate for the purposes of factor analysis.

One factor was extracted according to Kaiser's criterion (Field, 2009:647), which stipulates that factors with Eigenvalues larger than 1.0 must be extracted. Table 9.40.2 displays the total variance explained by this factor.

Table 9.40.2 Total variance explained by the one factor

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.364	78.784	78.784

According to Table 9.40.2 the above factor explained 78.78% of the variance.

The communalities were calculated referring to the percentage of each item's variance, which is accounted for by the single extracted factor. According to Hair et al. (1998) communalities should be larger than .3. This means that more than 30% of the variance of each item should be retained. The communalities for the items ranged from .604 to .851, which indicates that the extracted factor adequately accounted for the items and that not too much information was lost.
Only one factor emerged from the analysis, therefore it can be accepted that items 44 – 46 contribute towards designing effective assessment activities

The single factor that was extracted by the factor analysis and the items that rested on it were compared with the assessment strategies that are discussed in paragraphs 5.3 and 7.11. This comparison revealed many similarities, and one can conclude that the result of the factor analysis confirms the theoretical analysis and that the items in the questionnaire indeed relate to designing effective assessment activities that contribute towards effective OBA of Physical Sciences in the FET Band.

On the basis thereof this factor was labelled *designing assessment activities.*

9.6.2 Factor analysis 2: Aims of effective OBA (Items 47 – 51)

Table 9.41.1 gives information about Kaiser-Meyer-Oblimin measure of the sampling adequacy and the Bartlett's test of sphericity.

Table 9.41.1 Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.799
Bartlett's Test of Sphericity	Approx. Chi-Square	176.330
	Df	10
	Sig.	.000

According to Table 9.41.1, the Bartlet's test of sphericity resulted in a p-value smaller than .001, which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure is .799, which indicates that the sample size was adequate for the purpose of a factor analysis.

Using principal axis factoring, one factor was extracted. According to Kaiser's criterion (Field, 2009:647), factors with Eigenvalues larger than 1.0 must be extracted. Table 9.41.2 displays the variance explained by this factor.

Table 9.41.2 Total variance explained by one factor

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.333	66.660	66.660

According to Table 9.41.2 the above factor explained 66.66% of the variance.
As explained above (paragraph 9.6.1) the communalities for each item were calculated and the communalities for the five items ranged from .478 to .741. It can therefore be accepted that items 47 – 51 contributed towards the aims of effective assessment.

The single factor that was extracted by the factor analysis and the items that rested on it were compared with the assessment strategies that were discussed in paragraphs 5.6 and 7.8. This comparison revealed many similarities and one can conclude that the result of the factor analysis confirms the theoretical analysis. The items in the questionnaire indeed relate to the aims of assessment activities that contribute towards effective OBA of Physical Sciences in the FET Band.

On the basis thereof this factor was labelled *aims of Outcomes-Based-Assessment activities.*

9.6.3 Factor analysis 3: Principles of high quality assessment (Items 52 – 54)

Table 9.42.1 gives information about the Kaiser-Meyer-Olkin measure and the Bartlett's test of sphericity.

Table 9.42.1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.740
Bartlett's Test of Sphericity	Approx. Chi-Square	188.628
	Df	3
	Sig.	.000

Bartlett’s test of sphericity for the three items was found to be significant (p. < .0001), as shown by Table 9.42.1 above. This indicates that the items correlated with each other. The measure of sampling adequacy (i.e. Kaiser-Meyer-Olkin) indicated that the items have enough in common to justify factor analysis with a sampling adequacy of .740. This indicates that the sample size was adequate for the purpose of a factor analysis.

The principal axis factoring method was used to extract the factors from the three items (52 – 54), and one factor emerged. According to Kaiser’s criterion (Field, 2009:647), factors with Eigenvalues larger than 1.00 are significant. Table 9.42.2 displays the total variance explained by the factor.

Table 9.42.2: Total variance explained by one factor

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.663	88.762	88.762

According to Table 9.42.2, the above factor explained 88.76% of the total variance.

Communalities were calculated, representing the total amount of each item’s variance that is explained by the factor. The items had communality values that ranged from .694 to .921, indicating sufficient common variance among the items.

Only one factor emerged from the factor analysis, therefore it can be accepted that items 52 – 54 contribute towards principles of high quality assessment.

The single factor that was extracted by the factor analysis and the items that rested on it were compared to the principles of high quality assessment that are discussed in paragraphs 5.3.1, 5.4 and 5.5. This comparison revealed many similarities and one can conclude that the result of the factor analysis confirms the theoretical analysis and that the items in the questionnaire indeed relate to principles of high quality assessment that contribute towards effective OBA of Physical Sciences in the FET Band.

On the basis thereof this factor was labelled *principles of high quality assessment.*

9.6.4 Factor analysis 4: Outcomes-Based-Assessment strategies (Items 55 – 68)

In Table 9.43.1 information is given about the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett’s test of sphericity.

Table 9.43.1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.682
Bartlett's Test of Sphericity	Approx. Chi-Square	392.872
	Df	78
	Significance (p-value)	.000

Bartlett's test of sphericity resulted in a p-value smaller than .001, which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure is .682, which indicates that the sample size was adequate for the purposes of a factor analysis.

Three factors were extracted using the principle axis factor extraction method. According to Kaiser's criterion (Field, 2009), factors with Eigenvalues larger than 1.0 must be extracted. Table 9.43.2 shows the total variance explained by these three factors.

Table 9.43.2: Total variance explained by the three factors

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	4.570	35.155	35.155
2	2.268	17.446	52.601
3	1.432	11.014	63.615

According to Table 9.43.2 the above three factors explained 63.61% of the variance.

Communalities that refer to the percentage of each item's variance, which is accounted for by the four extracted factors, were of importance as well. According to Hair et al. (1998) communalities should be larger .3. This means that more than 30% of the variances of each item should be retained. The communalities ranged from .379 to .619, which indicated that the extracted factors adequately account for the items and that not too much information was lost.

The pattern matrix is presented in Table 9.43.3. In this table (Table 9.43.3) the factor loadings are given for the extracted factors on each item. The factor loadings indicate the correlation between the factors and the items.

Table 9.43.3 Pattern matrix 1: OBA strategies

Pattern Matrix[a]

	Factor		
	1	2	3
Debates	.797		
Essays	.746		
Performances	.729		.218
Presentations	.652		.209
Case Studies	.630		-.353
Exhibitions	.596		
Examinations	-.238	.816	
Tests		.799	
Research Projects	.216	.607	.212
Practical Tasks	.274	.554	
Assignments	.326	.518	-.415
Projects	.302	.373	.280
Portfolios			.589

The three factors that were extracted by the factor analysis and the items that loaded on them are compared to the assessment strategies that were discussed in paragraphs 6.4 and 7.11. Three factors were extracted. These are the factors that this study is interested in because they deal with the forms of assessment in OBA of Physical Sciences in the FET Band. The first factor is called "non-structured informal assessment tasks" because items like 'debates', 'essays', 'performances', 'presentations', 'case studies', and 'exhibitions' rested heavily on it. The second factor is called "structured formal assessment tasks" because items like 'examinations,' 'tests,' 'research projects,' 'practical tasks,' 'assignments,' and 'projects' rested heavily on it. The third factor is called "portfolio" because item 68, which enquires about portfolios, rested heavily on it.

On the basis of the above the factors were labelled and the following table gives information about the factors and their corresponding items.

Table 9.43.4: Assessment tasks' factors contributing towards effective assessment of Physical Sciences

Factors	**Items**
Non-structured Informal Assessment Tasks	56, 57, 60, 61, 63, 64
Structured Formal Assessment Tasks	55, 59, 62, 65, 66, 67
Portfolios	68

In Table 9.43.5 a correlation matrix is presented, which gives an indication of the extent to which the assessment task factors correlated with one another.

Table 9.43.5: Correlation matrix: Assessment tasks' factors

Factor Correlation Matrix

Factor	1	2	3
1	1.000	.281	.036
2	.281	1.000	.079
3	.036	.079	1.000

From the table above (Table 9.43.5) one can conclude that factor 1 (non-structured informal assessment tasks) showed a very small and thus insignificant correlation with factor 3 (portfolios), but a visible correlation with factor 2 (structured formal assessment tasks). Factor 2 (structured formal assessment tasks) showed a small correlation with factor 3 (portfolios), thus an insignificant correlation.

9.6.5 Factor analysis 5: Continuous Assessment (CASS) Benefits (Items 69 – 78)

In Table 9.44.1 information is given about the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity.

Table 9.44.1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.882
Bartlett's Test of Sphericity	Approx. Chi-Square	420.064
	Df	45
	Significance (p-value)	.000

Bartlett's test of sphericity resulted in a p-value smaller than .001 (Table 9.44.1), which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure is .882, which indicates that the sample size was adequate for the purposes of a factor analysis.

The two factors were extracted according to Kaiser's criterion (Field, 2009:647), which stipulates that factors with Eigenvalues larger than 1.0 must be extracted. Table 9.44.2 displays the total variance explained by these two factors.

Table 9.44.2: Total variance explained by the two factors

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	5.796	57.959	57.959
2	1.135	11.351	69.470

According to Table 9.44.2 above, the two factors explained 69.47% of the variance.
Extracted communalities were calculated, and the communality values ranged from .464 to .756, indicating a sufficient common variance among the items. According to Hair et al. (1998) communalities should be larger than .3. This means that more than 30% of the variance of each item should be retained.

In an effort to attain a simple structure, one type of rotation was undergone (i.e. Oblimin with Kaiser Normalization). Two factors were extracted as shown by the pattern matrix on Table 9.44.3 below. The factor loadings indicate the correlations between the factors and the items.

Table 9.44.3: Pattern matrix 2: Continuous assessment (CASS) benefits factors

Pattern Matrix[a]

	Factor	
	1	2
It provides feedback on the quality of learning and teaching	.951	
It allows for different assessment strategies	.911	
It allows for ways of giving feedback to learners about what was achieved by the assessment activity	.867	
It promotes valid and reliable assessment	.741	
It provides for a variety of learner needs through utilization of assessment strategies	.541	.339
A more extensive section of the curriculum can be covered by means of CASS	.540	.307
Learners set their own individual goals because they are involved in self-assessment		.785
It furthers learners' growth and development because they become active participants in the learning and assessment process		.679
Skills and concepts that are difficult to assess in examination/test situations can be assessed by means of CASS	.210	.557
It provides teachers with reliable information of learners' progress because their learning is regularly assessed throughout the year	.328	.425

The two factors that were extracted by the factor analysis and the items that rested on them were compared with the CASS benefits that are discussed in paragraphs 2.4 and 2.5. Two factors were extracted. The first factor is called "teacher oriented CASS benefits" because they are more oriented towards the teacher than the learners. Items such as 'it provides feedback on the quality of learning and teaching,' 'it allows for different assessment strategies,' 'it allows for ways of giving feedback to learners about what was achieved by the assessment activity,' 'it promotes valid and reliable assessment,,' 'it provides for a variety of learners needs through utilization of assessment strategies,' and 'a more extensive section of the curriculum can be covered by means of CASS' rested heavily on it. The second item is called "learner oriented CASS benefits" because items such as 'learners set their own individual goals because they become involved in self assessment,' 'it furthers learners' growth and development because they become active participants in the learning and assessment process,' skills and concepts that are difficult to assess in examination/test situation can be assessed by means of CASS,' and 'it provides teacher with reliable information of learners progress because their learning is regularly assessed throughout the year' rested heavily on it.

On the basis of the above the factors were labelled and the following table (Table 9.44.4) gives information about the factors and their corresponding items.

Table 9.44.4: CASS benefits contributing towards the effective assessment of Physical Sciences

Factors	Items
1. Teacher oriented CASS benefits	72, 73, 74, 75, 76, 77
2. Learner oriented CASS benefits	69, 70, 71, 78

In Table 9.44.5 a correlation matrix is presented that gives an indication of the extent to which CASS benefits factors correlate with one another.

Table 9.44.5: Correlation matrix: CASS benefits

Factor Correlation Matrix

Factor	1	2
1	1.000	.629
2	.629	1.000

According to Table 9.44.5, factor 1 (Teacher oriented CASS benefits) correlates significantly with factor 2 (Learner oriented CASS benefits).

9.7 VALIDITY AND RELIABILITY OF SUB-SECTION B5 OF THE QUESTIONNAIRE: EXPERIMENTATION AND PRACTICAL WORK

All the items (80 – 91) in this section of the questionnaire (Sub-section B5) dealt with participants' experiences with regard to the assessment of experiments and other practical work in the FET Band.

9.7.1 Factor analysis 1: Scientific Inquiry Skills (Items 81 – 84)

Table 9.45.1 below gives information about the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity.

Table 9.45.1 Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.597
Bartlett's Test of Sphericity	Approx. Chi-Square	35.066
	Df	6
	Significance (p-value)	.000

Bartlett's test of sphericity resulted in a p-value smaller that .001, which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure is .597, which indicates that the sample size was adequate for the purpose of a factor analysis. As indicated above, the Kaiser-Meyer-Olkin measure of adequacy should be greater than .5 for a satisfactory factor analysis to proceed (Neal, 2010).

One factor was extracted according to Kaiser's criterion (Field, 2009:647), which stipulates that factors with Eigenvalues larger than 1.0 must be extracted. Table 9.45.2 displays the total variance explained by this factor.

Table 9.45.2: Total variance explained by the single factor

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1.885	47.135	47.135

According to Table 9.45.2 the above factor explained 47.13% of the variance.
The extracted factor's communalities were calculated. According to Hair et al. (1998) communalities should be larger than .3. This means that more than 30% of the variance of each item should be retained.

The communalities ranged from .232 – 422, which indicated that the extracted factor inadequately accounted for one of the items and that some information was lost.

The factor that was extracted by the factor analysis and items that rested on it was compared to the strategies to teach learners scientific inquiry skills that were discussed in paragraphs 6.4.5 and 7.11. This comparison revealed many similarities and one can conclude that results of the factor analysis confirm the theoretical analysis and that the items in the questionnaire indeed relate to strategies to teach learners scientific inquiry skills.

Therefore, the emerged factor was called *scientific inquiry skills.*

9.7.2 Factor analysis 2: Challenges of practical work (Items 85 – 91)

In Table 9.46.1 information is given about the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity.

Table 9.46.1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.785
Bartlett's Test of Sphericity	Approx. Chi-Square	153.120
	Df	21
	Significance (p-value)	.000

Bartlett's test of sphericity resulted in a p-value smaller than .001, which indicates that the items correlated with each other. The Kaiser-Meyer-Olkin measure of sampling adequacy is .785, which indicated that the sample size was adequate for the purposes of a factor analysis.

Two factors were extracted according to Kaiser's criterion (Field, 2009:647), which stipulates that factors with Eigenvalues larger than 1.0 must be extracted. Table 9.46.2 displays the total variance explained by these factors.

Table 9.46.2: Total variance explained by the two factors

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.470	49.572	49.572
2	1.184	16.921	66.494

According to Table 9.46.2 above, the two factors explained 66.49% of the total variance.

The communalities were also calculated. They ranged from .375 to .689, which indicated that the extracted factors adequately accounted for the items and that not too much information was lost. According to Hair et al (1998) communalities should be larger than .3, meaning that more than 30% of the variance of each item should be retained.

The pattern matrix is presented in Table 9.46.3. In this table (Table 9.46.3) the factor loadings are given for the extracted factors on each item. The factor loadings indicate the correlations between the factors and the items.

Table 9.46.3: Pattern Matrix: Training in practical works, resources and departmental support

Pattern Matrix[a]

Items	Factor	
	1	2
My lack of training in practical work	.766	
My fear of causing accidents when practical work is done	.717	
Lack of knowledge of practical aspects and scientific inquiry	.676	
My inability to design assessment instruments that assess learner performance at different cognitive levels across all Learning Outcomes	.511	.298
Insufficient time for doing practical work		.811
Lack of departmental support (workshops)	.244	.637
The lack of resources at my school		.576

The two factors that were extracted by the factor analysis and the items that loaded on them were compared with challenges that prohibit the effective assessment of Physical Sciences as discussed in paragraphs 6.4.5 and 7.11. The first factor is called “training in practical work” because items like ‘my lack of training in practical work,’ ‘my fear of causing accidents when practical work is done,’ ‘lack of knowledge of practical aspects and scientific inquiry’ and ‘my inability to design assessment instruments that assess learner performance at different cognitive levels across all Learning Outcomes’ loaded highly on it. The second factor is called “resources and support” because items like ‘insufficient time for doing practical work,’ ‘lack of departmental support’ and the lack of resources at my school’ loaded highly on it.

On the basis of the above the factors were labelled and the following table (Table 9.46.4) gives information about the factors and their corresponding items.

Table 9.46.4: Challenges prohibiting effective assessment of Physical Sciences in the FET Band

Factors	Items
Training in practical work	85; 87; 88; 90
Resources and support	86; 89; 91

In Table 9.46.5 a correlation matrix is presented that gives an indication of the extent to which the factors correlate with one another.

Table 9.46.5: Correlation Matrix: Practical work

Factor Correlation Matrix

Factor	1	2
1. Training in practical work	1.000	.489
2. Resources and support	.489	1.000

From the above table (Table 9.46.5) one can conclude that factor 1 (training in practical work) correlates significantly with factor 2 (resources and support).

9.8 Synthesis of factor analyses: Sub-sections B4 & B5 of the questionnaire

After factor analyses were done on the items of Sub-sections B4 and B5, the following factors were derived as displayed below.

Sub-section B4

- Factor analysis 1: one factor emerged and was called *Designing Assessment Activities* (Items 44 – 46),
- Factor analysis 2: one factor emerged and was called *Aims of Outcome-Based-Assessment* (Items 47 – 51),
- Factor analysis 3: one factor emerged and was called *Principles of high quality assessment* (Items 52 – 54),
- Factor analysis 4: Three factors emerged and were called:
  - *Informal assessment tasks* (Items 56, 57, 60, 61, 63 & 64)
  - *Formal assessment tasks* (Items 55, 59, 62, 65, 66 & 67)
  - *Portfolio*s (Item 68),
- Factor analysis 5: Two factors emerged and were called:

- *Teacher oriented CASS benefits* (Items 72 - 77) and
- *Learner oriented CASS benefits* (Items 69, 70, 71, & 78)

Sub-section B5

- Factor analysis 1: one factor emerged and was called *Scientific Inquiry Skill* (Items 81 – 84,
- Factor analysis 2: Two factors emerged and were called:
  - *Training in practical work* (Items 85, 87, 88, & 90)
  - *Resources and support* (Items 86, 89, & 91).

9.9 Validity and reliability of Sub-sections B4 and B5 of the Questionnaire

In order to determine the reliability of Sub-sections B4 and B5 of the questionnaire, Cronbach's alpha coefficients were calculated. Tables 9.47 and 9.48 display the calculated alpha coefficients.

Table 9.47: Cronbach's Alpha Coefficients: Section B4

Factors	**Cronbach's alpha coefficients**
Effective OBA of Physical Sciences	
• Designing OBA activities	.861
• Aims of effective OBA	.877
• Principles of high quality assessment	.936
• Non-structured informal assessment tasks	.849
• Formal assessment tasks	.794
• Portfolio	.865
• Teacher oriented CASS benefits	.921
• Learner oriented CASS benefits	.780

The values of the alpha coefficients in Table 9.47 indicate that all these factors can be accepted as reliable.

Table 9.48: Cronbach's Alpha Coefficients: Section B5

Factors	Cronbach's alpha coefficients
Experimentation and practical work	
➢ Scientific inquiry skills	.616
➢ Lack of training in practical work	.802
➢ Lack of resources and departmental support	.746

The values of the alpha coefficients in Table 9.48 indicate that all these factors can be accepted as reliable

9.10 Synthesis: validity and reliability: Sub-sections B4 and B5 of the questionnaire

The construct validity of sub-sections B4 and B5 of the questionnaire was confirmed by the factor analyses (see Tables 9.17 to 9.46). These analyses identified the same factors related to effective OBA of Physical Sciences in the FET Band that was identified by the theoretical analysis in Chapters 2 – 7.

Cronbach's alpha coefficients in Tables 9.47 and 9.48 above confirm the reliability of Sub-sections B4 and B5 of the questionnaire.

9.11 THE RELATIONSHIP BETWEEN BIOGRAPHICAL VARIABLES AND FACTORS THAT CONTRIBUTE TOWARDS EFFECTIVE IMPLEMENTATION OF OBA OF PHYSICAL SCIENCES IN THE FET BAND

9.11.1 Remark

In this section the relationship between the different biographical variables and the factors that contribute towards effective implementation of OBA of physical sciences in the FET Band will be investigated. In order to do this the statistical methods of an independent t-test and analysis of variance (ANOVA) were employed.

The independent t-test was used in the cases where a biographical variable contained two response categories such as gender, school situation and possession of science apparatus. In order to determine whether statistically significant differences existed, p-values ($p < .05$) were consulted. Effect sizes

(Cohen's d-values) were then calculated to determine the practical significance of the differences (Cohen, 1988).

In cases where a biographical variable contained more than two categories, for example in the case of age (20 – 35 yrs, 36 – 40 yrs, 41+ yrs) ANOVA was used to determine whether statistically and practically significant differences existed. The omnibus test was initially used to determine whether statistically significant relationships existed between the different age categories and factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band. In this regard p-values smaller than 0.05 were regarded as statistically significant. Post-hoc tests were conducted to determine whether relationships were of practical significance and Cohen's d-values were then calculated to determine the practical significance.

The following guidelines were used to determine the practical significance of the determined d-values (Cohen, 1988):

$d \approx .2$	small practical significance
$d \approx .5$	medium practical significance
$d \approx .8$	large practical significance

9.11.2 The relationship between participants' gender and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Information regarding the relationship between participants' gender and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band are indicated in the table below (Table 9.49)

Table 9.49: The relationship between participants' gender and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Mean	Std. Deviation	t-test p-value	Effect sizes
Assessment of Physical Sciences in the FET Band						
Designing assessment activities	Male	38	3.13	.56	.493	0.16
	Female	33	3.04	.55		
Aims of effective Outcomes-Based Assessment	Male	38	3.40	.54	.704	0.09
	Female	33	3.35	.53		
Principles of high quality assessment	Male	38	3.41	.61	.346	0.22
	Female	33	3.27	.63		
Informal assessment tasks	Male	38	2.74	.71	.779	0.07
	Female	32	2.69	.68		
Formal assessment tasks	Male	38	3.40	.47	.887	0.03
	Female	32	3.41	.41		
Portfolio	Male	37	2.95	1.10	.737	0.08
	Female	32	3.03	1.00		
Teacher oriented CASS benefits	Male	38	3.08	.81	.092	0.34
	Female	34	3.35	.53		
Learner oriented CASS benefits	Male	38	2.97	.71	.167	0.28
	Female	34	3.17	.51		
Experimentation and practical work						
Scientific inquiry skills	Male	38	2.68	.53	.806	0.05
	Female	34	2.65	.65		
Lack of training in practical work	Male	38	1.68	.69	.297	0.23
	Female	33	1.52	.57		
Lack of resources and departmental support	Male	38	2.29	.87	.821	0.05
	Female	33	2.24	.87		

The small effect sizes (d – values) in Table 9.49 above indicate that there is no relationship between the participants' gender and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band. In other words, there were no significant differences between male and female participants in terms of the factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band.

9.11.3 The relationship between participants' age and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band

Table 9.50 below gives information about the relationship between participants' age and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with age will be reported in Table 9.50. Age categories 1 and 2 were not included in the analysis, because there were only 2 participants in category 1 (20 – 25 yrs), and 5 in category 2 (26 – 30 yrs), these eight participants were included in age category 3 (31 – 35 yrs).

Table 9.50: The relationship between participants' age and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	ANOVA p – values	Effect Sizes (d) 3 with	4 with
Assessment of OBA of Physical Sciences in FET Band							
Designing assessment activities	3. 20 - 35 yrs	21	2.97	.47	.976		
	4. 36 - 40 yrs	22	3.05	.52		0.15	
	5. 41 + yrs	27	3.19	.62		0.35	0.22
	Total	70	3.08	.55			
Aims of effective OBA	3. 20 - 35 yrs	21	3.28	.46	.092		
	4. 36 - 40 yrs	22	3.57	.44		0.65*	
	5. 41 + yrs	27	3.27	.62		0.00	0.48
	Total	70	3.37	.53			
Principles of high quality assessment	3. 20 - 35 yrs	21	3.22	.61	.306		
	4. 36 - 40 yrs	22	3.50	.56		0.46	
	5. 41 + yrs	27	3.30	.66		0.11	0.31
	Total	70	3.34	.62			
Informal assessment tasks	3. 20 - 35 yrs	20	2.81	.63	.102		
	4. 36 - 40 yrs	22	2.89	.69		0.11	
	5. 41 + yrs	27	2.49	.71		0.45	0.56*
	Total	69	2.71	.69			
Formal assessment tasks	3. 20 - 35 yrs	20	3.26	.44	.079		
	4. 36 - 40 yrs	22	3.56	.37		0.69*	

	5. 41 + yrs	27	3.38	.47		0.26	0.39
	Total	69	3.40	.44			
Portfolio	3. 20 - 35 yrs	20	2.75	1.07	.202		
	4. 36 - 40 yrs	23	3.30	.88		0.52*	
	5. 41 + yrs	25	2.96	1.10		0.19	0.31
	Total	68	3.01	1.03			
Teacher oriented CASS benefits	3. 20 - 35 yrs	21	3.00	.70	.123		
	4. 36 - 40 yrs	23	3.42	.68		0.61*	
	5. 41 + yrs	27	3.15	.69		0.22	0.39
	Total	71	3.19	.70			
Learner oriented CASS benefits	3. 20 - 35 yrs	21	3.01	.57	.432		
	4. 36 - 40 yrs	23	3.20	.66		0.28	
	5. 41 + yrs	27	2.97	.66		0.06	0.34
	Total	71	3.06	.63			
Experimentation and practical work							
Scientific inquiry skills	3. 20 - 35 yrs	21	2.54	.53	.380		
	4. 36 - 40 yrs	23	2.64	.67		0.16	
	5. 41 + yrs	27	2.77	.54		0.43	0.19
	Total	71	2.66	.58			
Lack of training in practical work	3. 20 - 35 yrs	20	1.56	.50	.757		
	4. 36 - 40 yrs	23	1.70	.64		0.21	
	5. 41 + yrs	27	1.59	.73		0.04	0.14
	Total	70	1.62	.64			
Lack of resources and departmental support	3. 20 - 35 yrs	20	2.54	.90	.251		
	4. 36 - 40 yrs	23	2.25	.77		0.32	
	5. 41 + yrs	27	2.12	.88		0.47	0.15
	Total	70	2.29	.86			

*d ≥ 0.5 (medium practical significance)

When the results in Table 9.50 are considered, relationships of medium practical significance are observed between certain age groups and some of the factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

For example:

A practically significant difference exists between the mean scores of the age group 20 to 35 years and the age group 36 to 40 years as far as the aims of effective OBA are concerned. It seems as if the older age group responded more positively to the items related to the aims of effective OBA than their younger counterparts did. The reason for this could be that the older age group are more experienced and are more aware of the purposes of OBA.

As far as informal assessment tasks are concerned, the mean scores of participants older than 41 years differ practically significantly from the mean score of the 36 to 40 years age group. The younger participants responded more positively to informal assessment tasks than their older counterparts did. The reason for this could be that the younger participants are more aware of the expanded opportunities that assessment should offer learners and the flexibility it deserves than the older participants.

The mean score of the age group 36 to 40 years old is significantly higher for formal assessment tasks than the mean score of the 20 to 35 years group. Thus, one can deduce that the older participants responded more positively towards formal assessment tasks than their younger colleagues did. It could be that most of the older participants' are more concerned about compliance (i.e. producing required number of assessment tasks recommended by NCS) than the younger participants. They also find informal assessment to be a burden and to add to their daily workload.

The mean score of the 20 to 35 year old age group also differs practically from the mean score of the 36 to 40 year old age group with regard to the use of portfolios. From this one can deduct that the older participants responded more positively towards the use of portfolios than the younger age group did. The reason for this may be that the younger participants are not suitably trained to develop year-long formal programme of assessment of Physical Sciences and are therefore more unaware of the importance of keeping the portfolio than the older participants.

Lastly, the mean score of 20 to 35 years old participants differs significantly from the mean score of the participants who are 36 to 40 years old with regard to teacher oriented CASS benefits. The older participants responded more positively towards teacher oriented CASS benefits than the younger participants. The reason for this could be that the older participants are more concerned about assessment task that will benefit the teacher more than the learners. That is, those assessment tasks that will provide the teacher with reliable information of learners' progress, provide feedback on the quality of learning and teaching, and promote validity and reliability in assessment.

Synthesis

From the above one can deduce that:

- Older participants responded more positively towards the aims of effective OBA than their younger counterparts.
- Younger participants responded more positively towards informal assessment tasks than older participants.
- Older participants responded more positively towards formal assessment tasks than their younger colleagues.
- Older participants responded more positively towards the use of portfolios than their younger counterparts.
- Older participants responded more positively towards teacher oriented CASS benefits than the younger participants.

9.11.4 The relationship between participants' overall teaching experience in years and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band

In Table 9.51 below information is given about the relationship between participants' overall teaching experience in years and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with participants' overall teaching experience in years will be reported in Table 9.51. Participants' overall teaching experience categories 1 (1yr) and 7 (30 + yrs) were not included in the analysis, because there was only 1 participant in each category. These 2 participants were included in overall teaching experience categories 2 (2 – 5 yrs) and 6 (21 – 30 yrs) respectively.

Table 9.51 The relationship between participants' overall teaching experience in years and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	ANOVA p - values	Effect sizes (d) 2 with	3 with	4 with	5 with
Effective OBA of Physical Sciences									
Designing assessment activities	2. 1 - 5 yrs	11	3.21	.50	.310				
	3. 6 - 10 yrs	13	3.00	.43		0.42			
	4. 11 -15 yrs	23	3.03	.58		0.32	0.05		
	5. 16 - 20 yrs	11	2.91	.45		0.61*	0.20	0.21	
	6. 21 - 30+ yrs	13	3.33	.71		0.17	0.47	0.43	0.60*
	Total	71	3.09	.55					
Aims of effective OBA	2. 1 - 5 yrs	11	3.42	.37	.219				
	3. 6 - 10 yrs	13	3.32	.49		0.20			
	4. 11 -15 yrs	23	3.50	.48		0.18	0.37		
	5. 16 - 20 yrs	11	3.05	.69		0.53*	0.39	0.65*	
	6. 21 - 30+ yrs	13	3.45	.60		0.05	0.21	0.10	0.57*
	Total	71	3.38	.53					
Principles of high quality assessment	2. 1 - 5 yrs	11	3.39	.49	.859				
	3. 6 - 10 yrs	13	3.23	.66		0.25			
	4. 11 -15 yrs	23	3.45	.60		0.09	0.33		
	5. 16 - 20 yrs	11	3.30	.48		0.19	0.11	0.24	
	6. 21 - 30+ yrs	13	3.28	.83		0.14	0.06	0.20	0.03
	Total	71	3.35	.62					
Informal assessment tasks	2. 1 - 5 yrs	11	2.65	.72	.004				
	3. 6 - 10 yrs	12	3.27	.52		0.86**			
	4. 11 -15 yrs	23	2.78	.59		0.17	0.85**		
	5. 16 - 20 yrs	11	2.60	.63		0.07	1.07**	0.27	
	6. 21 - 30+ yrs	13	2.25	.74		0.54*	1.38**	0.71*	0.47
	Total	70	2.72	.69					

Formal assessment tasks	2. 1 - 5 yrs	11	3.44	.51					
	3. 6 - 10 yrs	12	3.46	.40	.921	0.04			
	4. 11 -15 yrs	23	3.42	.42		0.04	0.09		
	5. 16 - 20 yrs	11	3.30	.34		0.28	0.41	0.30	
	6. 21 - 30+ yrs	13	3.40	.56		0.08	0.11	0.04	0.18
	Total	70	3.41	.44					
Portfolios`	2. 1 - 5 yrs	11	2.91	1.22					
	3. 6 - 10 yrs	13	3.00	.91	.934	0.07			
	4. 11 -15 yrs	23	3.13	1.01		0.18	0.13		
	5. 16 - 20 yrs	10	2.80	1.14		0.09	0.18	0.29	
	6. 21 - 30+ yrs	12	2.92	1.16		0.01	0.07	0.18	0.10
	Total	69	2.99	1.05					
Teacher oriented CASS benefits	2. 1 - 5 yrs	11	3.18	.72					
	3. 6 - 10 yrs	14	3.26	.61	.893	0.10			
	4. 11 -15 yrs	23	3.26	.77		0.09	0.00		
	5. 16 - 20 yrs	11	3.01	.81		0.22	0.31	0.31	
	6. 21 - 30+ yrs	13	3.25	.63		0.10	0.01	0.00	0.30
	Total	72	3.21	.70					
Learner oriented CASS benefits	2. 1 - 5 yrs	11	3.11	.58					
	3. 6 - 10 yrs	14	3.20	.51	.393	0.17			
	4. 11 -15 yrs	23	3.07	.66		0.06	0.21		
	5. 16 - 20 yrs	11	2.73	.83		0.46	0.58*	0.41	
	6. 21 - 30+ yrs	13	3.15	.52		0.08	0.09	0.13	0.52*
	Total	72	3.06	.63					
Experimentation and practical work									
Scientific inquiry skills	2. 1 - 5 yrs	11	2.43	.58					
	3. 6 - 10 yrs	14	2.71	.62	.435	0.46			
	4. 11 -15 yrs	23	2.66	.65		0.36	0.08		
	5. 16 - 20 yrs	11	2.91	.52		0.82**	0.31	0.38	
	6. 21 - 30+ yrs	13	2.62	.47		0.33	0.15	0.06	0.56*
	Total	72	2.67	.58					
Lack of training in practical work	2. 1 - 5 yrs	11	1.55	.42					
	3. 6 - 10 yrs	13	1.51	.61	.698	0.05			
	4. 11 -15 yrs	23	1.75	.67		0.31	0.36		
	5. 16 - 20 yrs	11	1.45	.40		0.24	0.11	0.46	

	6. 21 - 30+ yrs	13	1.63	.91		0.10	0.13	0.13	0.21
	Total	71	1.61	.64					
Lack of resources and departmental support	2. 1 - 5 yrs	11	2.32	.64	.737				
	3. 6 - 10 yrs	13	2.50	1.00		0.18			
	4. 11 -15 yrs	23	2.25	.83		0.09	0.25		
	5. 16 - 20 yrs	11	2.00	.76		0.42	0.50*	0.30	
	6. 21 - 30+ yrs	13	2.26	1.06		0.06	0.23	0.01	0.24
	Total	71	2.27	.86					

*d ≥ 0.5 (medium practical significance)

**d ≥ 0.8 (large practical significance)

When the results in the above table (Table 9.51) are considered, relationships of medium practical significance and large practical significance are observed between certain categories of teaching experience and some factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band.

For example:

Practically significant differences exist between the mean scores of the group of participants with teaching experience of 1 to 5 years and the group with 16 to 20 years of experience as far as the design of assessment activities are concerned. Practical significant differences can also be detected between the group of participants with 16 to 20 years of experience and the group of participants with 21 to 30+ years of experience as far as the design of assessment activities are concerned. It seems as if participants with teaching experience of 16 to 20 years responded less positively to the items related to the design of OBA activities than their less experienced and highly experienced counterparts. The reason for this could be that the more experienced participants lack practical knowledge of designing a work schedule for Physical Sciences.

Table 9.51 indicates that practically significant differences exist between the mean scores of the group of participants with teaching experience of 16 to 20 years and the groups with 1 to 5; 11 -15 and 21 to 30+ years with regard to the aims of effective OBA. One can deduce that the 16 to 20 years group responded less positively towards the items related to the aims of OBA than their counterparts. This means that the participants of the group 16 to 20 years' assessment activities are aimed to a lesser extent to develop learners' skills, knowledge, attitudes and values; assess learners' strengths and weaknesses; provide additional support to learners; revisit certain sections of the curriculum; and motivate and encourage learners. The reason for this could be that the participants of group 16 to 20 years are not aware of the purposes of CASS in OBA of Physical Sciences.

As far as informal assessment tasks are concerned, the mean score of participants with 6 to 10 years teaching experience differs practically significantly from the mean scores of the groups with respectively 1 to 5 years; 11 to 15 yrs; 16 to 20 years; and 21 to 30+ years teaching experience. The participants with 6 to 10 years teaching experience responded more positively to informal assessment tasks than their counterparts. Therefore, participants of this group showed a greater preference for informal assessment tasks such as presentations, debates, simulations, assignments case studies, essays, performances, and exhibitions than the other age groups. The reason for this could be that the less experienced participants are more aware of various assessment strategies than the more experienced participants. Furthermore, they might have enough time to administer, mark and record the mark.

The mean score of the group with 16 to 20 years of teaching experience is significantly lower with regard to learner-oriented CASS benefits than the mean scores of the groups with 6 to 10 years and 21 to 30+ yrs teaching experience. The 16 to 20 yrs group responded less positively to learner-oriented CASS benefits than their less experienced and their more experienced counterparts did. The participants for this group provide learners the opportunity to set their own individual goals. Their assessment does not provide for a variety of learner needs, it does not further learners' growth and development because learners are not active participants in the learning and assessment process. The reason for this could be that the less experienced participants are more concerned about giving learners enough opportunities to demonstrate competence in Physical Sciences than the older participants.

The mean score of the group with 16 to 20 years teaching experience also differs practically significantly from mean scores of the groups with 1 to 5 year and 21 to 30+ year teaching experience. Thus, one can deduce that the group with 16 to 20 year teaching experience responded more positively towards the use of scientific inquiry skills than their counterparts. This means that participants of this group use demonstrations, hands-on experiments, simulations and multimedia presentations during practical work. The reason for this could be that the schools where these teachers teach have practical resources and receive adequate departmental support. Furthermore, the more experienced participants are more knowledgeable about different scientific investigation strategies than their less experienced counterparts.

Lastly, the mean score of participants with 6 to 10 years teaching experience participants differs significantly from the mean score of the participants who have 16 to 20 years teaching experience. The more experienced participants (16 to 20 yrs teaching experience) responded less negatively about the lack of resources and departmental support than their less experienced participants (6 to 10 yrs teaching experienced). This means that the less experienced participants are more likely to be prohibited by a lack of resources and departmental support from using practical work to assess learners in Physical Sciences. The reason for this could be that they are less experienced and did not get adequate training in practical work. Moreover, the most experienced participants might be able to improvise more than the less experienced ones.

Synthesis

From the above one can deduce that:

- The participants with 16 to 20 years teaching experience responded less positively towards designing OBA activities than the groups with 6 to 10 yrs and 21 to 30+ years teaching experience.
- The group with 16 to 20 yrs teaching experience responded less positively towards the aims of effective OBA than the groups with 1 to 5 years, 6 to 10 years and 21 to 30+ teaching experience.
- The group with 6 to 10 years teaching experience responded more positively towards informal assessment tasks than their counterparts.
- The participants with 16 to 20 yrs teaching experience responded less positively towards learner-oriented CASS benefits than the participants with 6 to 10 yrs and 21 to 30+ yrs teaching experience.
- The group with 16 to 20 yrs teaching experience responded more positively towards scientific inquiry skills than the groups with 6 to 10 yrs and 21 to 30+ years teaching experience.
- The group with 16 to 20 yrs teaching experience responded less negatively towards lack of resources and departmental support than the group with 6 to 10 yrs teaching experience.

9.11.5 The relationship between participants' teaching experience as a Physical Sciences teacher in the FET Band in years and the different factors that contribute towards effective implementation of OBA in Physical Sciences in the FET Band

Information regarding the relationship between participants' teaching experience as a Physical Sciences teacher in the FET Band in years and the different factors that contribute towards the effective implementation of OBA in Physical Sciences in the FET Band can be observed in Table 9.52 below. Only those factors that displayed a medium to large relationship with the participants' Physical Sciences teaching experience will be reported in Table 9.36. The participants' Physical Sciences teaching experience category 1 (1 yr); category 6 (21 to 30 yrs) and category 7 (30 + yrs) were not included in the analysis. The reason for this was that there were only 4 participants in category 1 (1 yr) and these participants were included in category 2 (2 to 5 yrs). In categories 6 and 7, there were 7 and 1 participant/s respectively and these participants were included in category 5 (16 to 20 yrs).

Table 9.52 The relationship between participants' teaching experience as a Physical Sciences teacher in the FET Band in years and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	ANOVA p-values	Effect Sizes (d) 2 with	3 with	4 with
Effective OBA of Physical Sciences								
Designing assessment activities	2. 1 - 5 yrs	24	3.15	.48	.514			
	3. 6 - 10 yrs	16	3.00	.30		0.32		
	4. 11 - 15 yrs	15	2.96	.72		0.27	0.06	
	5. 16 + yrs	16	3.21	.68		0.08	0.31	0.35
	Total	71	3.09	.55				
Aims of OBA	2. 2 - 5 yrs	24	3.38	.47	.723			
	3. 6 - 10 yrs	16	3.31	.53		0.13		
	4. 11 - 15 yrs	15	3.51	.40		0.26	0.37	
	5. 16 + yrs	16	3.31	.73		0.10	0.00	0.27
	Total	71	3.38	.53				
Principles of high quality assessment	2. 1 - 5 yrs	24	3.39	.54	.368			
	3. 6 - 10 yrs	16	3.19	.54		0.37		
	4. 11 - 15 yrs	15	3.24	.86		0.17	0.07	
	5. 16 + yrs	16	3.54	.50		0.28	0.65*	0.35
	Total	71	3.35	.62				
Informal assessment tasks	2. 2 - 5 yrs	24	2.85	.61	.003			
	3. 6 - 10 yrs	15	3.00	.64		0.23		
	4. 11 - 15 yrs	15	2.79	.58		0.11	0.34	
	5. 16 + yrs	16	2.19	.72		0.92**	1.13**	0.83**
	Total	70	2.72	.69				
Formal assessment tasks	2. 1 - 5 yrs	24	3.51	.42	.378			
	3. 6 - 10 yrs	15	3.31	.40		0.48		
	4. 11 - 15 yrs	15	3.44	.41		0.18	0.31	
	5. 16 + yrs	16	3.30	.52		0.41	0.02	0.26
	Total	70	3.41	.44				
Portfolios	2. 1 - 5 yrs	23	2.96	1.15	.700			
	3. 6 - 10 yrs	16	3.13	.81		0.15		
	4. 11 - 15 yrs	15	2.73	1.22		0.18	0.32	

	5. 16 + yrs	15	3.13	.99		0.15	0.01	0.33
	Total	69	2.99	1.05				
Teacher oriented CASS benefits	2. 1 - 5 yrs	24	3.23	.63	.989			
	3. 6 - 10 yrs	17	3.19	.72		0.07		
	4. 11 - 15 yrs	15	3.16	.76		0.10	0.03	
	5. 16 + yrs	16	3.23	.78		0.01	0.05	0.08
	Total	72	3.21	.70				
Learner oriented CASS benefits	2. 1 - 5 yrs	24	3.06	.54	.468			
	3. 6 - 10 yrs	17	3.25	.53		0.35		
	4. 11 - 15 yrs	15	3.02	.76		0.06	0.31	
	5. 16 + yrs	16	2.91	.72		0.22	0.48	0.15
	Total	72	3.06	.63				
Experimentation and practical work								
Scientific inquiry skills	2. 1 - 5 yrs	24	2.63	.60	.875			
	3. 6 - 10 yrs	17	2.62	.51		0.01		
	4. 11 - 15 yrs	15	2.77	.73		0.19	0.20	
	5. 16 + yrs	16	2.69	.52		0.11	0.14	0.10
	Total	72	2.67	.58				
Lack of training in practical work	2. 1 - 5 yrs	23	1.62	.54	.916			
	3. 6 - 10 yrs	17	1.69	.65		0.10		
	4. 11 - 15 yrs	15	1.54	.56		0.15	0.23	
	5. 16 + yrs	16	1.56	.84		0.07	0.15	0.03
	Total	71	1.61	.64				
Lack of resources and departmental support	2. 1 - 5 yrs	23	2.37	.81	.819			
	3. 6 - 10 yrs	17	2.33	.81		0.04		
	4. 11 - 15 yrs	15	2.18	.94		0.21	0.17	
	5. 16 + yrs	16	2.14	.98		0.24	0.20	0.04
	Total	71	2.27	.86				

*d ≥ 0.5 (medium practical significance)

**d ≥ 0.8 (large practical significance)

When the results in the above table (Table 9.52) are considered, relationships of medium and large practical significance were observed between participants' teaching experience as Physical Sciences teachers in the FET Band in years and some of the factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

For example:

As far as principles of high quality assessment are concerned, the mean score of the participants with 16 + years differed practically significantly from the mean score of those with 6 to 10 years teaching experience as Physical Sciences teachers. Participants with 16 yrs and more teaching experience responded more positively to principles of high quality assessment than their counterparts with 6 to 10 yrs of teaching experience. This means that participants with 16 yrs and more teaching experience give more consideration to reliability, validity, and authenticity when they plan their assessment tasks than teachers with 6 to 10 yrs teaching experience. The reason for this could be that the more experienced participants are more concerned about the principles of high quality assessment than their less experienced colleagues.

Differences of practical significance also exist between the mean scores of teachers with 16+ yrs of teaching experience, and those with 2 to 5 years; 6 to 10 years; and 11 to 15 years of teaching experience as far as informal assessment tasks were concerned. It seems as if the most experienced participants responded less positively than their less experienced counterparts did. This means that the most experienced teachers' give less preference to informal assessment tasks such as presentations, debates, simulation, assignments, case studies, essays, performances, and exhibitions than their less experienced colleagues. The reason for this could be that the most experienced participants are more concerned about the development of skills and knowledge than about attitudes.

Synthesis

- The most experienced participants responded more positively towards principles of high quality assessment than their less experienced counterparts.
- The most experienced participants responded less positively towards informal assessment tasks than their less experienced counterparts.

9.11.6 The relationship between participants' highest teaching qualifications and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

In Table 9.53 below information is given about the relationship between participants' highest teaching qualifications and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with the participants' highest teaching qualifications will be reported in Table 9.53. Participants' highest teaching qualification categories 1 (Teaching certificate), 6 (M.Degree + Teaching diploma), and 7 (Ph.D + Teaching diploma) were not included in the analysis, because there was only 1 participant for category

1, and this participant was included in category 2 (Teaching diploma). There were 3 participants for category 6 and none for category 7. These 3 participants were included in category 5 (Hons.Degree or B.Ed. Hons).

Table 9.53 The relationship between participants' highest teaching qualifications and the different factors that contribute towards the effective implementation of OBA in the FET Band

Factors		N	Means	Std. Deviation	ANOVA p – values	Effect Sizes (d) 2 with	3 with	4 with
Effective OBA of Physical Sciences								
Designing assessment activities	2. Teacher Certificate/diploma	18	2.98	.48	.859			
	3. Teaching degree	16	3.13	.64		0.22		
	4. B-degree + Teaching diploma	13	3.13	.55		0.27	0.00	
	5. Hons. Degree + M.Degree + Teaching diploma	22	3.09	.57		0.19	0.05	0.07
	Total	69	3.08	.55				
Aims of OBA	2. Teacher Certificate/diploma	18	3.31	.59	.584			
	3. Teaching degree	16	3.51	.41		0.34		
	4. B-degree + Teaching diploma	13	3.40	.59		0.15	0.19	
	5. Hons. Degree + M.Degree + Teaching diploma	22	3.28	.55		0.05	0.42	0.20
	Total	69	3.37	.53				
Principles	2. Teacher Certificate/diploma	18	3.30	.57	.866			
	3. Teaching degree	16	3.29	.54		0.01		
	4. B-degree + Teaching diploma	13	3.46	.52		0.29	0.31	
	5. Hons. Degree + M.Degree + Teaching diploma	22	3.30	.76		0.01	0.01	0.21
	Total	69	3.33	.61				
Informal assessment tasks	2. Teacher Certificate/diploma	17	2.81	.78	.927			
	3. Teaching degree	17	2.75	.63		0.09		
	4. B-degree + Teaching diploma	12	2.65	.58		0.21	0.15	
	5. Hons. Degree + M.Degree + Teaching diploma	22	2.69	.78		0.16	0.08	0.05
	Total	68	2.73	.70				

Formal assessment tasks	2. Teacher Certificate/diploma	17	3.49	.50	.474			
	3. Teaching degree	17	3.39	.40		0.19		
	4. B-degree + Teaching diploma	12	3.24	.48		0.50*	0.32	
	5. Hons. Degree + M.Degree + Teaching diploma	22	3.45	.40		0.08	0.14	0.44
	Total	68	3.41	.44				
Portfolio	2. Teacher Certificate/diploma	16	2.88	1.20	.686			
	3. Teaching degree	17	2.94	.97		0.05		
	4. B-degree + Teaching diploma	13	3.31	.95		0.36	0.38	
	5. Hons. Degree + M.Degree + Teaching diploma	22	2.91	1.11		0.03	0.03	0.36
	Total	68	2.99	1.06				
Teacher oriented CASS benefits	2. Teacher Certificate/diploma	18	3.27	.72	.738			
	3. Teaching degree	17	3.29	.56		0.03		
	4. B-degree + Teaching diploma	13	3.06	.73		0.29	0.32	
	5. Hons. Degree + M.Degree + Teaching diploma	22	3.12	.80		0.20	0.22	0.07
	Total	70	3.19	.70				
Learner oriented CASS benefits	2. Teacher Certificate/diploma	18	3.18	.74	.491			
	3. Teaching degree	17	3.16	.66		0.03		
	4. B-degree + Teaching diploma	13	3.07	.66		0.15	0.14	
	5. Hons. Degree + M.Degree + Teaching diploma	22	2.90	.50		0.38	0.40	0.26
	Total	70	3.07	.63				
Experimentation and practical work								
Scientific inquiry skills	2. Teacher Certificate/diploma	18	2.64	.59	.419			
	3. Teaching degree	17	2.54	.55		0.17		
	4. B-degree + Teaching diploma	13	2.56	.71		0.12	0.02	
	5. Hons. Degree + M.Degree + Teaching diploma	22	2.83	.55		0.32	0.52*	0.38
	Total	70	2.66	.59				
Lack of training in practical work	2. Teacher Certificate/diploma	18	1.57	.54	.285			
	3. Teaching degree	17	1.59	.78		0.02		
	4. B-degree + Teaching diploma	13	1.93	.71		0.51*	0.44	
	5. Hons. Degree + M.Degree + Teaching diploma	21	1.51	.52		0.11	0.10	0.59*
	Total	69	1.62	.64				

Lack of resources and departmental support	2. Teacher Certificate/diploma	18	2.07	.84				
	3. Teaching degree	17	2.63	.95	.038	0.58*		
	4. B-degree + Teaching diploma	13	2.59	.88		0.58*	0.04	
	5. Hons. Degree + M.Degree + Teaching diploma	21	1.96	.68		0.14	0.70	0.71
	Total	69	2.27	.87				

*d ≥ 0.5 (medium practical significance)

When the results in the above table are analysed, relationships of medium practical significance are observed between the highest teaching qualification and some factors that contribute towards effective assessment of Physical Sciences in the FET Band.

For example:

The mean score of the participants with a teacher certificate or teaching diploma was significantly higher for formal assessment tasks than the mean score of the participants with B-degrees and a teaching diploma. From this one can deduce that the less qualified participants responded more positively towards formal assessment tasks than the more qualified participants did. It seems as if less qualified teachers' assessment tasks were more dominated by tests, examinations and projects than participants with higher qualifications. The reason for this could be that the less qualified participants are more concerned about compliance than the participants with higher qualifications. Furthermore, the less qualified participants might be restricted by inadequate knowledge of different assessment strategies.

Practically significant differences existed between the mean scores of the group of participants with a teaching degree and the group of participants with an Hons or M-Degree plus a teaching diploma as far as scientific inquiry skills were concerned. The more qualified participants responded more positively to the items related to scientific inquiry skills than the less qualified participants did. This means that highly qualified teachers showed more preference to demonstrations, hands-on experiments, simulations, and multimedia presentations to teach learners scientific inquiry skills than their lesser qualified counterparts did. The reason for this could be that the more highly qualified teachers were more suitably trained to teach Physical Sciences in FET Band than their lesser qualified colleagues were.

As far as a lack of training in practical work is concerned, the mean score of participants with a B-degree and a teaching diploma differed significantly from the mean scores of teachers with a teacher certificate or diploma. The mean score of participants with an Hons Degree or M. Degree plus a teaching diploma also differed significantly from the mean score of participants with a B-degree and a teaching diploma. Participants with a B-degree and teaching diploma responded more positively towards a lack of training in practical work than the less qualified and the highest qualified groups of participants. This means that participants with B-degree and teaching diploma were more likely to be inhibited by a lack of training in practical work than their colleagues. The reason for this could be that the training they received was not adequate enough to enable them to conduct practical work that promotes OBA in Physical sciences.

Lastly, practically significant differences existed between the mean scores of the participants with a teaching certificate or diploma and participants with a teaching degree with regard to a lack of resources and departmental support. A similar difference was found between the mean scores of participants with a teaching certificate/diploma and participants with a B-degree and a teaching diploma. The mean score of participants with a honours, master's degree plus a teaching diploma also differed significantly from the mean scores of participants with a teaching degree, or a B-degree plus teaching diploma. From this one could deduct that the participants with the higher qualifications responded less positively towards a lack of resources and departmental support than their less qualified counterparts. This means that participants with the higher qualifications are less likely to be inhibited by a lack of resources and departmental support when assessing their learners in doing practical work and experiments in Physical Sciences. The reason for this could be that the participants with higher qualifications are better qualified to implement OBA of Physical Sciences in the FET Band.

Synthesis

From the above one can deduce that:

- Participants with lower teaching qualifications are more inclined towards formal assessment tasks than their more highly qualified counterparts.
- Participants with the highest qualifications responded more positively towards scientific inquiry skills than their less qualified counterparts.
- Participants with a B-degree and teaching diploma were more likely to be inhibited by a lack of training in practical work than their colleagues.
- Participants with higher qualifications were less likely to be inhibited by a lack of resources and departmental support when assessing their learners in doing practical work and experiments in Physical Sciences.

9.11.7 The relationship between participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Table 9.54 below gives information about the relationship between participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective assessment of Physical Sciences in the FET Band. Only those sub-factors that displayed a medium to large relationship with the participants' highest qualification in Physical Sciences/Physics/Chemistry will be reported. Qualification categories 1 (Grade 12) and 2 (1st year tertiary level) were not included in the analysis, because there was only 1 participant in category 1, and 2 participants in category 2. These participants were therefore included in category 3 (2nd year tertiary level). Categories 5 and 6 were also not included in the analysis because there was only 1 participant in category 5 (Masters Degree) and none in category 6 (Doctors degree). The participant with a master's degree was included in category 4 (Hons. Degree).

Table 9.54 The relationship between participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	t-test p-values	Effect sizes (d)
Effective OBA of Physical Sciences						
Designing assessment activities	3. Grade 12 - 2nd year tertiary	27	3.06	.55	.765	0.07
	4. 3rd year tertiary - Doctorates	42	3.10	.58		
Aims of OBA	3. Grade 12 - 2nd year tertiary	27	3.38	.49	.903	0.03
	4. 3rd year tertiary - Doctorates	42	3.36	.57		
Principle of high quality assessment	3. Grade 12 - 2nd year tertiary	27	3.27	.52	.518	0.14
	4. 3rd year tertiary - Doctorates	42	3.37	.67		
Informal assessment task	3. Grade 12 - 2nd year tertiary	28	2.60	.73	.242	0.28
	4. 3rd year tertiary - Doctorates	40	2.81	.68		
Formal assessment task	3. Grade 12 - 2nd year tertiary	28	3.37	.46	.623	0.12
	4. 3rd year tertiary - Doctorates	40	3.42	.43		
Portfolio	3. Grade 12 - 2nd year tertiary	27	2.70	1.20	.110	0.37
	4. 3rd year tertiary - Doctorates	40	3.15	.92		
Teacher oriented CASS benefits	3. Grade 12 - 2nd year tertiary	28	2.96	.82	.031	0.49
	4. 3rd year tertiary - Doctorates	42	3.36	.58		
Learner oriented CASS benefits	3. Grade 12 - 2nd year tertiary	28	2.93	.74	.182	0.30
	4. 3rd year tertiary - Doctorates	42	3.14	.52		
Experimentation and practical work						
Scientific Inquiry Skills	3. Grade 12 - 2nd year tertiary	28	2.57	.57	.279	0.26
	4. 3rd year tertiary - Doctorates	42	2.72	.60		

Lack of training in practical work	3. Grade 12 - 2nd year tertiary	28	1.49	.42	.148	0.28
	4. 3rd year tertiary - Doctorates	41	1.70	.75		
Lack of resources and departmental support	3. Grade 12 - 2nd year tertiary	28	2.21	.74	.548	0.13
	4. 3rd year tertiary - Doctorates	41	2.34	.95		

*d ≥ 0.5 (medium practical significance)

According to Table 9.54 above, the relatively small effect sizes (d – values) indicate that there was no practically significant relationship between the participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective assessment of Physical Sciences in the FET Band.

Synthesis

There was no relationship between the participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

9.11.8 The relationship between participants' positions at school and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Table 9.55 below gives information regarding the relationship between participants' positions at school and the different factors that contribute towards the effective implementation of OBA in Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with the participants' position in school will be reported. The position categories 3 (deputy principal) and 4 (principal) were not included in the analysis. The reason for this is that there were only 2 participants in each category and these participants were included in category 2 (Head of Department).

Table 9.55 The relationship between participants' positions at school and the different factors that contribute towards the effective implementation OBA in Physical Sciences in the FET Band

Factors		**N**	**Means**	**Std. Deviation**	**t-test p-values**	**Effect Sizes (d)**
Effective OBA of Physical Sciences						
Designing assessment activities	1. Teacher	44	3.02	.54	.207	0.31
	2. HOD - Principal	27	3.20	.57		
Aims of OBA	1. Teacher	44	3.37	.57	.847	0.04
	2. HOD - Principal	27	3.39	.48		
Principles high quality assessment	1. Teacher	44	3.35	.60	.986	0.00
	2. HOD - Principal	27	3.35	.66		
Informal assessment tasks	1. Teacher	43	2.77	.71	.460	0.17
	2. HOD - Principal	27	2.64	.66		
Formal assessment Tasks	1. Teacher	43	3.46	.42	.179	0.33
	2. HOD - Principal	27	3.31	.46		
Portfolio	1. Teacher	44	3.02	1.02	.706	0.09
	2. HOD - Principal	25	2.92	1.12		
Teacher oriented CASS benefits	1. Teacher	45	3.22	.72	.776	0.07
	2. HOD - Principal	27	3.18	.68		
Learner oriented CASS benefits	1. Teacher	45	3.10	.68	.492	0.15
	2. HOD - Principal	27	3.00	.54		
Experimentation and practical work						
Scientific inquiry skills	1. Teacher	45	2.67	.64	.989	0.00
	2. HOD - Principal	27	2.67	.50		
Knowledge of practical work	1. Teacher	44	1.61	.57	.915	0.02
	2. HOD - Principal	27	1.60	.75		
Resources and departmental support	1. Teacher	44	2.41	.82	.078	0.42
	2. HOD - Principal	27	2.03	.90		

The relatively small effect sizes in Table 9.55 above indicates that there is no significant relationship between the participants' positions at school and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band. This means that there were no significant differences between teachers, HOD's and principals in terms of the factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

Synthesis

It can be deducted that there was no relationship between the participants' position at school and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

9.11.9 The relationship between participants' school location and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Information regarding the relationship between participants' school location and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band can be observed in Table 9.56. Only those factors that displayed a medium to large relationship with the school location will be reported.

Table 9.56 The relationship between participants' school location and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	t-test p-values	Effect Sizes (d)
Effective OBA of Physical Sciences						
Designing assessment activities	1. Rural	54	3.04	.54	.168	0.40
	2. Urban	16	3.27	.59		
Aims of OBA	1. Rural	54	3.38	.54	.968	0.01
	2. Urban	16	3.39	.52		
Principles of high quality assessment	1. Rural	54	3.32	.56	.730	0.09
	2. Urban	16	3.40	.80		
Informal assessment task	1. Rural	52	2.76	.70	.329	0.27
	2. Urban	17	2.57	.69		
Formal assessment task	1. Rural	52	3.37	.43	.302	0.29
	2. Urban	17	3.51	.47		
Portfolio	1. Rural	52	2.98	1.02	.955	0.02
	2. Urban	16	3.00	1.21		
Teacher oriented CASS benefits	1. Rural	54	3.21	.71	.960	0.01
	2. Urban	17	3.20	.72		

Learner oriented CASS benefits	1. Rural	54	3.06	.63	.857	0.05
	2. Urban	17	3.09	.65		
Experimentation and practical work						
Scientific inquiry skills	1. Rural	54	2.66	.59	.863	0.05
	2. Urban	17	2.63	.54		
Training in practical work	1. Rural	53	1.54	.57	.157	0.38
	2. Urban	17	1.84	.80		
Resources and departmental support	1. Rural	53	2.32	.90	.333	0.24
	2. Urban	17	2.11	.75		

Table 9.56 above indicates that there was no significant relationship between the participants' school's location (rural and urban) and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

Synthesis

From Table 9.56 above it can be deducted that there was no relationship between the participants' school location and the factors that contribute towards the effective implementation of OBA of Physical Sciences in FET Band.

9.11.10 The relationship between the availability of electricity at the participants' schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

The availability of electricity at the participants' schools was not included in the analysis, because only one participant indicated that his/her school did not have electricity (see Table 9.9).

9.11.11 The relationship between the availability of running water at the participants' schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

The availability of running water at the participants' schools was not included in the analysis because only three participants indicated that there was no running water in their schools (see Table 9.10).

9.11.12 The relationship between the grade/s that participants taught Physical Sciences to and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

The grade/s participants taught Physical Sciences to was not included in the analysis because there was an unequal distribution of participants' responses to this variable (see Table 9.11).

9.11.13 The relationship between the average number of learners in the participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Table 9.57 below indicates the relationship between the average number of learners in the participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with the average number of learners in the Physical Sciences classes will be reported in Table 9.57. Categories 5 (51 – 60 learners) and 6 (61 – 70 learners) were not included in the analysis because there were only three participants in Category 5 and one participant in Category 6. These participants were included in Category 4 (41 – 50 learners).

Table 9.57 The relationship between the average number of learners in the participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	ANOVA p – values	Effect Sizes (d) 1 with	2 with	3 with
Effective OBA of Physical Sciences								
Designing assessment activities	1. 10 - 20	17	3.06	.57	.113			
	2. 21 - 30	15	3.31	.51		0.44		
	3. 31 - 40	13	3.23	.53		0.30	0.15	
	4. 41 - 70	25	2.91	.56		0.27	0.73*	0.58*
	Total	70	3.09	.56				
Aims of OBA	1. 10 - 20	17	3.15	.58	.212			
	2. 21 - 30	15	3.51	.42		0.61*		
	3. 31 - 40	13	3.49	.58		0.58*	0.02	
	4. 41 - 70	25	3.37	.52		0.37	0.27	0.22

	Total	70	3.37	.53				
Principles of high quality assessment	1. 10 - 20	17	3.39	.60	.643			
	2. 21 - 30	15	3.33	.82		0.07		
	3. 31 - 40	13	3.49	.48		0.16	0.19	
	4. 41 - 70	25	3.23	.56		0.27	0.13	0.47
	Total	70	3.34	.62				
Informal assessment task	1. 10 - 20	17	2.68	.71	.782			
	2. 21 - 30	15	2.59	.70		0.13		
	3. 31 - 40	13	2.86	.68		0.25	0.38	
	4. 41 - 70	24	2.73	.72		0.08	0.20	0.17
	Total	69	2.71	.70				
Formal assessment tasks	1. 10 - 20	17	3.22	.42	.011			
	2. 21 - 30	15	3.58	.41		0.86**		
	3. 31 - 40	13	3.64	.43		0.98**	0.15	
	4. 41 - 70	24	3.29	.41		0.17	0.70*	0.81**
	Total	69	3.40	.44				
Portfolio	1. 10 - 20	16	2.88	1.02	.045			
	2. 21 - 30	14	2.50	1.22		0.31		
	3. 31 - 40	13	3.62	.87		0.72*	0.91**	
	4. 41 - 70	25	2.96	.93		0.08	0.38	0.70*
	Total	68	2.97	1.05				
Teacher oriented CASS benefits	1. 10 - 20	17	3.15	.81	.019			
	2. 21 - 30	15	3.07	.79		0.10		
	3. 31 - 40	13	3.73	.34		0.71*	0.84**	
	4. 41 - 70	26	3.03	.59		0.15	0.05	1.18**
	Total	71	3.19	.70				
Learner oriented CASS benefits	1. 10 - 20	17	2.87	.73	.360			
	2. 21 - 30	15	3.00	.65		0.18		
	3. 31 - 40	13	3.27	.46		0.55*	0.41	
	4. 41 - 70	26	3.09	.60		0.30	0.13	0.31
	Total	71	3.05	.62				
Experimentation and practical work								
Scientific inquiry skills	1. 10 - 20	17	2.53	.62	.503			
	2. 21 - 30	15	2.83	.53		0.49		
	3. 31 - 40	13	2.63	.56		0.17	0.36	
	4. 41 - 70	26	2.63	.56		0.16	0.37	0.01
	Total	71	2.65	.57				

Training in practical work	1. 10 - 20	17	1.53	.41	.100			
	2. 21 - 30	15	1.32	.36		0.50*		
	3. 31 - 40	13	1.90	.84		0.44	0.69*	
	4. 41 - 70	25	1.66	.72		0.18	0.47	0.29
	Total	70	1.60	.64				
Resources and departmental support	1. 10 - 20	17	2.36	.82	.002			
	2. 21 - 30	15	1.62	.47		0.91**		
	3. 31 - 40	13	2.15	.85		0.25	0.63*	
	4. 41 - 70	25	2.66	.90		0.33	1.16**	0.56*
	Total	70	2.27	.87				

*d ≥ 0.5 (medium practical significance)

**d ≥ 0.8 (large practical significance)

When the results in the above table (Table 9.57) are observed, relationships of medium to large practical significance were observed between the average number of learners in participants' Physical Sciences classes and certain factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

For example:

Practically significant differences existed between the mean scores of the participants with 21 to 30 and 41 to 70 learners in their Physical Sciences classes as far as the designing assessment tasks is concerned. Similar differences were also found between the mean scores of participants with 31 to 40 and 41 to 70 learners in their classes. Participants with the largest class groups (41 to 70 learners) responded less positively to items related to designing assessment activities than their counterparts with smaller class groups.

The mean scores of the participants with 10 to 20 learners in the Physical Sciences classes group was significantly lower regarding the aims of OBA than the mean scores of participants with 21 to 30 and 31 to 40 learners in their class groups. It seems as if participants with smaller class groups were to a lesser extent concerned with the aims of assessment in their assessment activities, than their counterparts with larger class groups. This finding seems to contradict the previous finding and it is not possible for the researcher to offer a logical explanation for this.

As far as formal assessment tasks are concerned, the mean score of the participants with 10 – 20 learners in their Physical Sciences classes differed practically significantly from the mean scores of participants with respectively 21 to 30 and 31 to 40 learners in their classes. The mean score of participants with 41 to 70 learners in their Physical Sciences classes also differed practically significantly from the mean scores of participants with 21 to 30 and 31 to 40 learners in their classes. Thus, it seems as if participants with 31 to 40 learners in their classes responded more positively to items related to structured formal assessment tasks, than their counterparts did. This implies that participants with 31 to 40 learners in their Physical Sciences classes showed more preference for formal assessment tasks such as projects, assignments, tests, examinations, practical work, and research projects than their counterparts with smaller and larger class groups. Marks allocated to structured formal assessment tasks are recorded and normally form part of the learner's participation mark. It is possible that teachers with smaller class groups could have more time to devote to informal assessment tasks and that teachers with large class groups (more than 40 learners) could find marking, recording and reporting of structured assessment tasks a very cumbersome responsibility.

The mean score of participants with 31 to 40 learners in Physical Sciences classes differed practically significantly from the mean scores of teachers with 10 to 20, 21 to 30 and 41 to 70 learners in their classes with regard to the use of portfolios. It seems as if participants with 31 to 40 learners in their classes responded more positively towards the use of portfolios than their counterparts. This implies that, participants with 31 to 40 learners in their Physical Sciences classes believed that the use of portfolios could to a large extent contribute towards the effective assessment of Physical Sciences in the FET Band. There is no logical explanation for this finding.

The mean score of the participants with 31 to 40 learners in Physical Sciences classes also differed practically significantly from the mean scores of participants with 10 to 20; 21 to 30; and 41 to 70 learners in their classes in terms of their responses to items related to CASS oriented teacher benefits. From this one can deduce that participants with 31 to 40 learners in their classes responded more positively towards teacher-oriented CASS benefits items than their counterparts. This implies that, participants with 31 to 40 learners in their Physical Sciences classes designed assessment tasks with the following in mind: to provide feedback on the quality of learning and teaching, to give feedback to learners about what was achieved by the assessment activity, to allow for different assessment strategies, to provide for a variety of learner needs through utilization of assessment strategies, to promote valid and reliable assessment, and to cover more extensive sections of the curriculum. Reasons for this finding are unknown and the researcher does not wish to speculate further about this.

As far as the learner-oriented assessment tasks are concerned, the mean score of the participants with 31 to 40 learners in their Physical Sciences classes group differed practically significantly from the mean score of the participants with 10 to 20 learners in their classes. Participants teaching to the larger class group (31 to 40 learners) responded more positively to the items related to learner-oriented CASS benefits than teachers teaching to smaller group (10 to 20 learners). No logical explanations can be offered for this finding.

Practically significant differences existed between the mean scores of participants with 21 to 30 learners in their classes and participants who have respectively 10 to 20 learners, and 31 to 40 learners in their classes as far their training in practical work is concerned. Participants with 21 to 30 learners in Physical Sciences classes responded more positively to their training in practical work than their counterparts did. This means that participants with 21 to 30 learners in their Physical Sciences classes were to a lesser extent restricted by a lack of training in practical work than their colleagues. It is possible that participants teaching in these classes with 21 to 30 learners were better trained to conduct practical work.

Lastly, the mean score of participants with 21 to 30 learners in their Physical Sciences classes differed significantly from the mean scores of participants with respectively 10 to 20, 31 to 40, and 41 to 70 learners in their classes in so far as their responses to a lack of resources and departmental support were concerned. From this finding one can deduct that participants with 21 to 30 learners in their Physical Sciences classes felt less restricted by a lack of resources and departmental support to conduct practical work than their counterparts. This particular finding indirectly supports the finding in the above paragraph that teachers with 21 to 30 learners in their classes felt less restricted to conduct practical work in their classes.

Synthesis

From the above one can deduce that:

- Participants with the larger number of learners in their Physical Sciences classes responded less positively towards designing assessment activities than their counterparts who teach to a smaller number of learners.
- Participants with a smaller number of learners in their Physical Sciences classes responded less positively towards the aims of OBA than their counterpart with larger number of learners.
- Participants with an average number (31 to 40) of learners in their classes responded more positively towards formal assessment tasks than their counterparts with smaller and larger number of learners.
- Participants with an average (31 to 40) number of learners in their Physical Sciences classes responded more positively towards use of portfolios than their counterparts who teach smaller and larger number of learners.
- Participants with an average (31 to 40) number of learners in their Physical Sciences classes responded more positively towards teacher-oriented CASS benefits than their counterparts teaching to smaller and larger number of learners.
- Participants with a larger number of learners in their Physical Sciences classes responded more positively towards learner-oriented CASS benefits than their counterparts teaching to a smaller number of learners.

- Participants with 21 to 30 learners in their Physical Sciences classes felt less restricted by lack of training in practical work than their counterparts who teach to smaller class groups.
- Participants with 21 to 30 of learners in their Physical Sciences classes felt less restricted by a lack of resources and departmental support than their counterparts who teach to smaller and larger class groups.

9.11.14 The relationship between the availability of a science laboratory in participants' schools and the different factors that contribute towards the effective implementation of OBA of physical Sciences in the FET Band

Table 9.58 gives the information about the relationship between the availability of science laboratories in participants' schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

Table 9.58 The relationship between the availability of a science laboratory in the participants' schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Factors		N	Means	Std. Deviation	t-test p-values	Effect Sizes (d)
Effective OBA of Physical Sciences						
Designing assessment activities	1. Yes	47	3.1064	.59428	.438	0.09
	2. No	24	3.0556	.47819		
Aims of OBA	1. Yes	47	3.4298	.52912	.917	0.29
	2. No	24	3.2750	.53670		
Principles high quality assessment	1. Yes	47	3.3901	.55742	.657	0.17
	2. No	24	3.2639	.72218		
Informal assessment tasks	1. Yes	48	2.6507	.72988	.249	0.29
	2. No	22	2.8621	.58800		
Formal assessment tasks	1. Yes	48	3.4236	.47135	.621	0.12
	2. No	22	3.3674	.36430		
Portfolio	1. Yes	47	3.0638	.98696	.463	0.21
	2. No	22	2.8182	1.18065		
Teacher oriented CASS benefits	1. Yes	48	3.2257	.68724	.433	0.08
	2. No	24	3.1653	.74357		

Learner oriented CASS benefits	1. Yes	48	3.0052	.60787	.731	0.26
	2. No	24	3.1771	.66545		
Experimentation and practical work						
Scientific inquiry skills	1. Yes	48	2.6719	.52379	.569	0.02
	2. No	24	2.6597	.70064		
Knowledge of practical work	1. Yes	47	1.6383	.70374	.560	0.13
	2. No	24	1.5451	.48714		
Resources	1. Yes	47	2.2163	.88117	.129	0.17
	2. No	24	2.3681	.83692		

The small effect sizes (d – values) in Table 9.58 above indicate that there is no relationship between the availability of science laboratories at the participants' schools and the different factors that contribute towards the effective assessment of Physical Sciences in the FET Band. The reason for this finding may be that most schools in the North-West Province make use of either the Small-Scale Chemistry Set apparatus or the Somerset-Micro-Set when doing practical work (refer to Table 9.13). In the absence of science laboratories, the aforementioned apparatus makes it possible to conduct practical work in the classrooms.

9.11.15 The relationship between the availability of apparatus to do practical work (experiments) in participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

Table 9.59 gives information about the relationship between the availability of apparatus to do practical work (experiments) in participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band. Only those factors that displayed a medium to large relationship with the availability of apparatus to do practical work (experimentation) in participants' Physical Sciences classes will be reported.

Table 9.59 The relationship between the availability of apparatus to do practical work (experiments) in participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band.

FACTORS		N	Means	Std. Deviation	t-test p-values	Effect Sizes (d)
Effective OBA of Physical Sciences						
Designing assessment activities	1. Yes	62	3.11	.54		
	2. No	9	2.93	.66	.438	0.28
Aims of OBA	1. Yes	62	3.37	.51		
	2. No	9	3.40	.69	.917	0.04
Principles high quality assessment	1. Yes	62	3.36	.62		
	2. No	9	3.26	.62	.657	0.16
Informal assessment tasks	1. Yes	62	2.76	.67		
	2. No	8	2.40	.79	.249	0.46
Formal assessment tasks	1. Yes	62	3.42	.42		
	2. No	8	3.31	.56	.621	0.19
Portfolio	1. Yes	61	2.95	1.06		
	2. No	8	3.25	1.04	.463	0.28
Teacher oriented CASS benefits	1. Yes	63	3.24	.67		
	2. No	9	2.98	.90	.433	0.28
Learner oriented CASS benefits	1. Yes	63	3.08	.60		
	2. No	9	2.97	.84	.731	0.12
Experimentation and practical work						
Scientific inquiry skills	1. Yes	63	2.69	.55		
	2. No	9	2.53	.79	.569	0.20
Lack of training in practical work	1. Yes	62	1.59	.62		
	2. No	9	1.75	.78	.560	0.21
Lack of resources and departmental support	1. Yes	62	2.21	.87		
	2. No	9	2.65	.73	.129	0.50*

*d ≥ 0.5 (medium practical significance)

A difference of medium practical significance was detected between the participants' "yes" and "no" responses with regard to a lack of resources and departmental support. This indicates that the participants' ability to conduct experiments and practical work are restricted by a lack of resources and departmental support.

9.11.16 The relationship between the types of apparatus participants do have at their schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band

Due to the unequal distribution of participants' responses, this relationship was not further analysed.

9.11.17 The relationship between medium of instruction used by participants to teach Physical Sciences at their various schools and different factors that contribute to the effective implementation of OBA of Physical Sciences in the FET Band

The medium of instruction that participants use to teach Physical Sciences at their schools was not further analysed because of the unequal distribution of responses. Most of the participants (75%) indicated that they use English as the medium of instruction and very few indicated that they used different languages or alternated between languages.

9.12 SUMMARY OF FINDINGS EMANATING FROM THE RELATIONSHIP BETWEEN THE DIFFERENT BIOGRAPHICAL VARIABLES AND THE FACTORS THAT CONTRIBUTE TOWARDS EFFECTIVE IMPLEMENTATION OF OBA OF PHYSICAL SCIENCES IN THE FET BAND

In responding to the secondary research question: Is there a relationship between the different biographical variables and factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band, the following findings were made:

- No relationship was found to exist between the participants' gender and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band (refer to Table 9.49).

- Relationships between participants' age and factors that contribute towards the effective implementation of OBA were found to exist (see Table 9.50). For example:
    - Older participants (36 to 40) responded more positively towards the aims of effective OBA than their younger counterparts (20 to 35).
    - Younger participants (20 to 35) responded more positively towards informal assessment tasks than older participants (36 to 40).
    - Older participants (36 to 40) responded more positively towards formal assessment tasks than their younger colleagues (20 to 35).
    - Older participants (36 to 40) responded more positively towards the use of portfolios than their younger counterparts (20 to 35).

- Older participants (36 to 40) responded more positively towards teacher oriented CASS benefits than their younger participants (20 to 35).

- Relationships were found to exist between the participants' overall teaching experience in years and factors that contribute towards the effective implementation of OBA (refer to Table 9.51). For example
  - The participants with 16 to 20 years teaching experience responded less positively towards designing OBA activities than the groups with 6 to 10 yrs and 21 to 30+ years teaching experience.
  - The group with 16 to 20 yrs teaching experience responded less positively towards the aims of effective OBA than the groups with 1 to 5 years, 6 to 10 years and 21 to 30+ teaching experience.
  - The group with 6 to 10 years teaching experience responded more positively towards informal assessment tasks than their counterparts.
  - The participants with 16 to 20 yrs teaching experience responded less positively towards learner-oriented CASS benefits than the participants with 6 to 10 yrs and 21 to 30+ yrs teaching experience.
  - The group with 16 to 20 yrs teaching experience responded more positively towards scientific inquiry skills than the groups with 6 to 10 yrs and 21 to 30+ years teaching experience.
  - The group with 16 to 20 yrs teaching experience responded less negatively towards lack of resources and departmental support than the group with 6 to 10 yrs teaching experience.

- The findings indicate that in the following cases relationships existed between participants' teaching experience as a Physical Sciences teacher and factors that contribute towards the effective implementation of OBA (refer to Table 9.52). For example:
  - The most experienced participants (16 years and more) responded more positively towards principles of high quality assessment than their less experienced participants.
  - The most experienced participants (16 years and more) responded less positively towards informal assessment tasks than the less experienced participants.

- The findings indicate that in the following cases, relationships existed between participants highest qualifications and factors that contribute towards the effective implementation of OBA (see table 9.53):
  - Participants with the higher qualifications (B-degrees and teaching diplomas) responded less positively towards formal assessment tasks than their less qualified counterparts.

- Participants with the highest qualifications (Hons. or Masters degree plus teaching diploma) responded more positively towards scientific inquiry skills than the less qualified participants did.
- Participants with higher qualifications (B-degree plus teaching diploma) responded more positively towards a lack of knowledge of practical work than the less and highest qualified participants.
- Participant with a higher qualification (B-degree plus teaching diploma) responded less positively towards a lack of resources and departmental support than their less qualified counterparts.

- There was no relationship between the participants' highest qualifications in Physical Sciences/Physics/Chemistry and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band (refer to Table 9.54).

- There was no relationship between the participants' position at school and the different factors that contribute towards effective implementation of OBA of Physical Sciences in the FET Band (see Table 9.55).

- There was no relationship between the participants' school location (urban/rural) and the factors that contribute towards the effective implementation of OBA of Physical Sciences in FET Band (refer to Table 9.56).

- A relationship was found to exist between the number of learners in the participants' Physical Sciences classes and the different factors that contribute towards the effective implementation of OBA (see Table 9.57). For example:
  - Participants with a larger number (41 to 70) of learners in Physical Sciences classes responded less positively towards designing OBA activities than their counterparts with a smaller number of learners (31 to 40).
  - Participants with a smaller number of learners (10 to 20) in their Physical Sciences classes responded less positively towards aims of OBA than their counterparts with a larger number of learners (21 to 30 and 31 to 40).
  - Participants with an average number of learners (31 to 40) in their Physical Sciences classes responded more positively towards formal assessment tasks than their counterparts with smaller and larger numbers of learners (10 to 20 and 41 to 70).
  - Participants with an average number of learners (31 to 40) in their Physical Sciences classes responded more positively regarding the use of portfolios than their counterparts with smaller and larger numbers of learners.

  - Participants with an average number of learners (31 to 40) in their Physical Sciences classes responded more positively regarding teacher-oriented CASS benefits than their counterpart with smaller and larger numbers of learners.
  - Participants with an average number of learners (31 to 40) in Physical Sciences classes responded more positively towards learner-oriented CASS benefits than their counterparts with a smaller number of learners (10 to 20).
  - Participants with 21 to 30 of learners in their Physical Sciences classes responded less positively regarding a lack of knowledge of practical work than their counterparts with smaller and larger numbers of learners.
  - Participants with 21 to 30 learners in their Physical Sciences classes responded less positively towards a lack of resources and departmental support than their counterparts with smaller and larger numbers of learners.

- There was no relationship between the availability of science laboratories at the participants' schools and the different factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band (see Table 9.58).

- The participants who responded "no" to a lack of resources and departmental support were less restricted when it comes to conducting experiments and practical work than their counterparts who responded "yes" (refer to Table 9.59).

9.13 QUALITATIVE RESULTS

Participants were requested to express their opinion in writing on the following unstructured (open-ended) items of section B of the questionnaire (see Appendix D): 1B1, 2B1, 1B2, 1B5, 2B5, 3B5, 4B5, 5B5, 1B6, and 2B6 (refer to Appendix B for verbatim responses). Their written responses to items were qualitatively analysed (see paragraph 8.4.6.2for process of qualitative data analysis) and categorised.

9.13.1 Written responses to item 1B1 of Sub-Section B1: Reasons for responding that standards of OBA were poor or very poor

If participants responded to Item 20 that the standard of OBA of Physical Sciences in the FET Band was poor or very poor (Item 20), they could motivate their response.

A total of four out of 72 participants motivated their response to Item 20 and their motivations were categorised as follows:

- Category A: Not enough time spent on training
- Category B: Incompetent trainers

- Category C: Training was too theoretical and lacked practical application value
- Category D: Trainer's content knowledge were inadequate

9.13.2 Responses to item 2B1 of Sub-Section B1: Reasons for a lack of confidence to implement OBA in FET Band

If participants indicated that they were not confident to implement OBA of Physical Sciences in the FET Band (Item 21), they could comment on the reasons for their lack of confidence.

A total of seven out of 72 participants wrote comments that can be categorised as follows:

- Category A: Inadequate training
- Category B: Incompetent trainers
- Category C: The training was too theoretical and lacked practical application value

9.13.3 Responses to item 1B2 of Sub-Section B2: What is lacking in the NCS documents

If participants responded to Items 37 and 38 that the NCS documents were not easy to understand and did not contain clear guidelines for implementation (Items 37 & 38), they could comment on what they think was lacking in the documents.

Of the 72 participants, only three (3) responded, and their responses were categorised as follows:

- Category A: Documents were not easy to understand
- Category B: The curriculum documents implied an excessive workload
- Category C: The curriculum is overloaded
- Category D: The curriculum is irrelevant

9.13.4 Responses to item 1B5 of Sub-Section B5: Reasons for learners not conducting the experiments

If participants responded to Item 80 that their learners did not at all conduct experiments, they could comment on what prohibited learners from conducting experiments.
Only ten (10) participants out of 72 responded, and their responses are categorised as follows:

- Category A: A lack of resources to conduct experiments
- Category B: Teachers were inadequately trained to conduct practical work
- Category C: The workload and overloaded curriculum does not allow time for experimentation

9.13.5 Response to item 2B5 of Sub-Section B5: Reasons for not using or inadequately using OBA strategies to teach learners scientific inquiry skills during practical work

If participants indicated that they not at all or to a small extent use the OBA strategies indicated by Items 81 – 84, they could give reasons for their response.

Of the 72 participants, 31 responded, and their reasons for not using or inadequately using OBA strategies to teach learners scientific inquiry skills during practical work were categorised as follows:

- Category A: Lack of resources
- Category B: Overcrowded classes
- Category C: Overloaded curriculum
- Category D: Lack of media resources
- Category E: Limited teaching time

9.13.6 Responses to item 3B5 of Sub-Section B5: Reasons for not using practical methods (e.g. experiments) when assessing learners in Physical Sciences

If participants marked the response categories "to a considerable extent" or "to a large extent" for any of items 85 – 91, i.e. problems/challenges prohibiting teachers from using practical methods when thy asses their learners in Physical Sciences, they could state the reason/s for such response/s.

Of the 72 participants 24 responded, and their responses were categorised as follows:

- Category A: Lack of resources
- Category B: Overcrowded classes
- Category C: Overloaded curriculum
- Category D: Limited teaching time
- Category E: Lack of departmental support

9.13.7 Responses to item 4B5 of Sub-Section B5: How do teachers usually assess learners' practical work?

Participants were requested to explain how they usually assess their learners' practical work and 52 out of the possible 72 participants responded to this item (item 4B5). Their responses were categorised as follows:

- Category A: Using a rubric and/or using memorandum

- Category B: Using worksheets
- Category C: Conducting observations and/or using a report form

9.13.8 Responses to item 5B5 of Sub-Section B5: Opinions about the moderation of practical work by Subject Specialists

Participants were invited to give their opinions about the moderation of practical work in Physical Sciences by Subject Specialists.

Of the 72 possible participants, 52 participants responded to this item and their opinions were categorised as follows:

POSITIVE

- Category A: Quality of the moderation was good
- Category B: Quality of the moderation was fair
- Category C: Moderation supports teachers

NEGATIVE

- Category A: Subject Specialists are incompetent to moderate
- Category B: Few Subject Specialists
- Category C: Moderation is inadequate
- Category D: Moderation is limited to Grade 12

Proposals made to enhance the moderation of practical work

- Category A: Workshops about the moderation of practical work should be called at the beginning of every term
- Category B: Subject Specialists should be appreciative of teachers' work
- Category C: Common assessment tool should be used

9.13.9 Responses to item 1B6 of Sub-Section B6: Comments about the OBA of Physical Sciences in the FET Band

Participants were invited to give any positive and/or negative comments about Outcomes-Based Assessment of Physical Sciences in the FET Band.

Positive comments

Forty of the possible 72 participants gave positive comments about the OBA of Physical Sciences and their responses were categorised under the following categories:

- It is good
- It is inclusive
- It provides for different assessment opportunities
- It is learner centred

Negative

31 out of the 72 participants gave their negative comments about the OBA of Physical Sciences and their responses were categorised under the following categories:

- Category A: OBA causes work overload
- Category B: Teachers experience a lack of resources
- Category C: The curriculum is overloaded in terms of content
- Category D: Teachers experience a lack of departmental support
- Category E: There is a lack in training or inadequate training on effective assessment
- Category F: Some concepts related to assessment are incoherent
- Category G: The NCS is very difficult to implement and to understand
- Category H: Learners' abilities to master the subject content knowledge are inadequate

9.13.10 Responses to item 2B6 of Sub-Section B6: Inputs to improve OBA of Physical Sciences in the FET Band

Participants were invited to make suggestions on what can be done to improve the OBA of Physical Sciences in the FET Band.

Forty-two out of the possible 72 participants gave suggestions, and these were grouped under the following categories:

- Category A: Allow more time for teaching
- Category B: Reduce the administrative workload
- Category C: Provide more resources
- Category D: Streamline the curriculum and reduce the overload
- Category E: Enhance departmental support

- Category F: Improve training
- Category G: Improve the coherence of concepts
- Category H: Simplify the implementation of OBA
- Category I: Allow more time for learners to master content knowledge and basic concepts

9.14 Discussion of Qualitative results

This section offers a discussion of the qualitative results.

9.14.1 Reasons for responding that the standard of OBA training was poor or very poor

9.14.1.1 Not enough time spent on training

Participants complained about the amount of time spent on training by making comments such as: "*limited time frame" and that "it was a crash course and not a detailed developmental workshop as we expected, since this was a completely new concept"*. This is a serious concern as no educational changes can be implemented successfully if enough time is not dedicated to the training of the people who have to implement the changes. Table 9.18 indicates that only 38.89% of the participants received training in the implementation of the OBA for a period of one week and longer. This means that about 61.11% of the participants received training in the implementation of OBA for periods of less than one week, while others received no training at all. In order for training to be effective, more time must be spent on developing the teachers and engaging them in the practical application of new policies. This fact is stressed by Reyneke (2008:144), who quotes Black and William (2001:2) as saying that *"fundamental educational change can only be achieved slowly – through programmes of professional development that build on existing good practice"*.

9.14.1.2 Incompetent trainers

It transpired from the participants' responses that the training that they have received was not adequate enough to enable them to implement the OBA of Physical Sciences effectively because they were trained by incompetent trainers who could not respond to their questions. One participant aired his/her frustration by stating that "*I still have a lot of problems in understanding the underlying principles of AOB* (meaning OBA)*. It appears the actual AOB we talk about is not the one that is in place at the moment".* The cause of this confusion may be brought about by the fact that *"training was done by our teacher colleques* (referring to colleagues) *whom in my opinion I think they find it difficult as well".* It would be highly unlikely for in-service teachers to be prepared for a so-called paradigm shift in their approach to teaching and assessment if facilitators could neither give them a clear overview of what OBE entailed, nor answer any particular questions related to it (Reyneke, 2008:143).

9.14.1.3 Training was too theoretical and lacked practical application value

The short duration of the training did not allow for practical application of OBA. Moreover, as training was conducted by individuals who seemed to be incompetent with OBA of Physical Sciences themselves (paragraph 9.7.1.2), there was no way practical application was imminent. One participant indicated that *"the training was done theoretically"* and went further to state that "*demonstrations should have been done in class with the learners to see if OBE is possible."* Indeed *"it was a crash course and not a detailed developmental workshop as we expected, since this was a completely new concept".* The Department of Education did not make preparations to train teachers. A number of researchers have identified important components that make development programmes more effective, especially when the aim is to change practice as well as ideas. These components include (Onwu & Mogari, 2004:165): presentation of ideas and modelling; trialling and practice; reflection and feedback; assistance and support. The training of teachers for the implementation of OBA of Physical Sciences in the FET Band contained none of these components or those mentioned in the paragraphs below.

9.14.1.4 Teachers' content knowledge

It is clear from the participants' responses that training in OBA was done in isolation from the subject content to be taught, despite the fact that some teachers who teach Physical Science in the FET Band were not suitably qualified to do so. Table 9.6 indicates that although most teachers were professionally well qualified, 40% of the participants completed less than a three year tertiary course in Physical Sciences.

One of participants' commented about training that *"Content went out the back door. That still remains the most important issue!!! Many teachers are not capable to handle the new content, what will the learners learn? How are you supposed to get 70 – 80% for a subject that your teacher knows 40 – 50% off?* This comment indicates that not only do some teachers experience problems with the curriculum, but also with the content that is supposed to be taught to Physical Sciences learners. According to Reyneke (2008:143), literature makes it clear that it is impossible to successfully implement change in an education system if serious investments are not made in the professional development of teachers.

9.14.2 Reasons for lack of confidence to implement OBA in FET Band

9.14.2.1 Inadequate training

The participants indicated their concerns relating to the quality of the training they received. They experienced the training as inadequate and felt that it would not enable them to successfully implement the curriculum. Participants voiced their frustration by making comments such as: *"If one is not properly* *trained, there is no way one can implement or impart information to others or put to practice what one has learned"* This participant's statement implies that despite the amount of subject knowledge one has, if the curriculum is not clearly understood by the teacher, it will be very difficult to impart information to learners.

9.14.2.2 Incompetent trainers

The use of incompetent trainers by the Department of Education is one factor that resulted in participants lacking confidence in the implementation of the OBA of Physical Sciences in the FET Band. This finding is underlined by one participant who commented that *"Our trainers themselves were not that confident while rendering training"*. This state of affairs negatively affects the confidence of teachers, because they doubt the accuracy of the information they received from their trainers. That is why one of them commented that he/she is "*not sure whether I'm doing the right thing or not"* and *"Maybe I should not be so very confident. Because the question is: Am I really doing the correct thing according to the books?"*

9.14.2.3 Training was too theoretical and lacked practical application value

Some participants also indicated that the training was simply too theoretical in nature and that little or no attention was paid to the practical implementation of the OBA of Physical Sciences in the FET Band. In this regard some of the participants commented as follows:*"I have not received any training which can help me to confidently implement OBA, the educators who attended some workshops say they were not given feedback on the assessment that they did, therefore they do not completely understand want* (what) *OBA is about"*. Some of the participants were confused because they tried their best to implement the OBA in schools, but because of inadequate training the results are still disappointing. One participant said that *"With the method*, *learners seem not to relate well with the teacher. Learners cannot work on their own even with guidance or supervision"*. Another participant commented that teachers are *"still struggling to design practical investigation".*

9.14.3 What is lacking in the NCS documents?

Participants' comments on the NCS documents are discussed below:

9.14.3.1 It is not easy to understand

Teachers experienced difficulties comprehending the complex nature and full extent of assessment practices, and were as a result tardy in the implementation of the OBA of Physical Sciences in the FET Band (Reynecke, 2008:158 and Warnich, 2008:282). As indicated by some of the participants above, *"guidance is too complicated for implementation ……..".* This means that there are still some teachers who do not understand the policy documents. There seems to be a gap between the curriculum documents and its practical implementation, which is a concern. Nonetheless, as far as assessment is concerned, the gap between policy and practice does not only exist in South Africa, but also in countries such as US, Australia and England (Warnich, 2008:282).

9.14.3.2 Workload implied by curriculum documents

Some participants found the NCS documents difficult to implement and responded that it contained too much information. Furthermore, some complained that the assessment guidelines in the curriculum documents implied much paperwork on the side of teachers, which would add to the existing workload of teachers and learners. According to the Subject Assessment Guidelines for Physical Sciences (DoE, 2005a), assessment is an integral part of teaching and learning. For this reason, assessment should be part of every lesson and teachers should plan assessment activities to complete learning activities. The curriculum document states that "In addition to daily assessment, teachers should develop a year-long formal Programme of Assessment for each subject" (DoE, 2005a:2), in this case Physical Sciences. For Physical Sciences, a total of seven (7) tasks must be undertaken during the school year and must be recorded. These tasks include two examinations (Mid-year exam and End-of-year exam) for Grades 10 & 11. Excluding the end-of-year exam, the CASS mark and the practical work (Performance tasks) accounts for one third of the end-of-year examination mark (that is 25% of the final mark). In Grade 12, the final examination is externally set and moderated (refer to paragraph 7.11.2). Participants were of the opinion that CASS adds heavily to the workloads of teachers and learners by stating that *"too much time is wasted on paper work rather than teaching".*

9.14.3.3 Overloaded curriculum

Some participants found the NCS documents to be overloaded with *"too much information, too much paper-work"* while another participant indicated that *"content is too much to complete very well. Very detail ensuring learners understand it very well and can apply. Too long content too little time".* According to another participant, "*the volume of content to be presented to learners has increased such that one does not have enough time to satisfactorily complete the content such that learners understand it very well*".

9.14.3.4 Irrelevant curriculum

Some participants commented that *"they are missing a point, we want more technicians, engineers etc. At the moment or the current trend we will definitely end up with less. We will still have doctors and engineers but no technicians, no fitters, and turners and electricians".* These comments indicate that some teachers find the curriculum content irrelevant and they think that the curriculum is not addressing the need for artisans and technologists in our country.

9.14.4 Reasons for learners not conducting the experiments

Although most participants instructed their learners to conduct experiments (practical work) as stipulated in the NCS, about 15.27% of the participants (table 9.22) still felt that they were not doing enough and gave reasons for not instructing their learners to conduct practical work. It is important to note that in this study "practical work" refers to those learning-teaching situations in which learners are given the opportunity to practise the processes of investigation (refer to paragraph 6.4.5). These would involve (Stoffels, 2005:148) any 'hands-on', 'minds-on' practical learning opportunity where learners practice and develop various process skills such as questioning, observing, hypothesising, predicting and collecting, recording, analysing and interpreting data. Participants' responses are presented and discussed in the categories below:

9.14.4.1 Lack of resources to conduct experiments

Some participants complained about the lack of resources to do practical work. Where there are resources they are insufficient or participants had to rely on external sources for conducting practical work. In this regard some of the participants commented that *"there are no resources which are sufficient for learners to carry out experiments and even a demonstration by the educators".* The participants went on to indicate that *"the equipment in the lab is not working or the chemicals are long expired".* Other participants commented that the "*school does not have a laboratory",* or that *"there are no apparatus, no laboratory, and no DVD".* One participant commented that the school solely relies on external sources for conducting experiments*: "there is a mobile laboratory which visit the school once a term"*. This means that if the particular company stops the project, no practical work will be conducted in this and other schools. It is a serious source of concern that despite the fact that the NCS emphasises the importance of practical work in the OBA of Physical Sciences in the FET Band, there are still schools that do not at all conduct practical work. The question is raised how the learners earn their marks in practical work, because according to Learning Programme Guidelines (DoE, 2005a:3), the marks of two practicals must be recorded per school per year in all the FET grades (see paragraph 7.11.2). In addition to a lack of resources to conduct practical work, some schools have overcrowded classrooms.

9.14.4.2 Inadequate training to conduct practical work

Some participants put the blame for their failure to successfully implement the OBA of Physical Sciences in the FET Band on inadequate initial training or no training at all. It is shocking to realise that there are teachers who are implementing the curriculum without having undergone training on the curriculum. Of the 14 participants who indicated that they did not receive training in OBA (Table 9.2), only one gave it as a reason for learners not conducting practical work at his/her school. This is despite the fact that practical work contributes to the learners' CASS mark. It should be noted that of the 7 tasks that should be recorded, two of these tasks should be practical work.

9.14.4.3 Workload inhibits practical work

Some participants said that one of the reasons why learners do not conduct experiments was the workload caused by the implementation of the curriculum. Some participants were Heads of the Departments (HOD's) who lamented that their responsibilities as HOD's restricted them from instructing learners to conduct practical work. One HOD said that *"My reason for learners not conducting more experiments: Being the H.O.D. I am moderating work of other educators which is using up a lot of unnecessary time. Impromptu meetings at school and other nitty gritty's is consuming time which I could have channelled into preparing more experiments.* The participant went on to say, *"A few years back we had to do 8 experiments per year, I remember it taking ±1 hour to prepare the apparatus & worksheets beforehand".* The participant further aired his/her dissatisfaction by indicating that *"I will gladly do it (experiments) instead of checking other teachers' work that gets paid for doing their work".* The participant is frustrated because he/she is not doing the work he/she is supposed to do, and in addition to that the participant has to do the work of other teachers who get paid for work they do not do because the HOD is the one who is actually doing the work. All these activities add to his/her workload. Another participant stressed the fact that the curriculum has added more work to their workload by indicating that *"the most Physics and Maths Educators I have met are H.O.D's, the administration is taking us out of classes! Help!!!".* This frustrated HOD calls for help from the Department of Education. Not only are the participants overloaded with work, but the learners are as well. One of the participants feels that *"Learners are doing many subjects which consume the time that learners could be using to conduct experiments".* Research (Warnich & Wolhurter, 2008:74; Reyneke, 2008:147) has also indicated that the introduction of OBE has increased the teachers' and learners' workload. Teachers are faced with loads of work because of difficult subject content; limited teaching time; and an overloaded curriculum: *"Experiments depends on the type of content being taught at that point in time, some are difficult to undertake due to lack of appropriate resources, whereas some content is purely theoretical*"; *The only time available is for teaching. The educator is often covering the bigger scope of the schedule and the time is very short"; "The syllabus is also too long and need more time to cover it – on the other side learners should also be assessed and time is also needed for that".*

9.14.5 Reasons for not using or inadequately using OBA strategies to teach learners scientific inquiry during practical work

Although scientific inquiry is pivotal to science teaching, most participants do not use, or inadequately use effective strategies to teach their learners scientific inquiry skills during practical work (Table 9.38) due to the reasons discussed below.

9.14.5.1 Lack of resources

Some participants indicated that they do not have the necessary apparatus to conduct practical work (Table 9.14). Other participants indicated that they not at all use hands-on experiments (conducted by learners) to teach scientific inquiry skills and others use hands-on experiments to a small extent. A small number of participants use demonstrations to teach learners scientific skills.

Some participants explained that a lack of resources is the reason for not using, or inadequately using demonstrations and/or experimentations to teach learners scientific inquiry skills. They said that *"Limited resources …..."; due to limited resources and overcrowding in class"; We don't have the resources at school, it can't be done, because we don't even have projectors at school ………."; No resources available to be able to perform this task"; "No laboratory, no chemicals – for proper demonstration, or hands-on experiment to be done learners need to travel to nearby education centre; it consumes time; cause conflict with other teachers to take learners away for a day or two".* One participant indicated that *"Resources are not adequate, laboratory not to standard, apparatus just packed i.e. labs not functional only improvisation".*

9.14.5.2 Overcrowded classes

Another obstacle that prevents participants to successfully implement OBA is overcrowded classrooms. One of the participants stated that they did not use strategies that teach learners inquiry skills because of *"Limited space > and class overcrowdings".*

9.14.5.3 Overloaded curriculum

Another reason for teachers not using effective strategies to teach learners scientific inquiry skills is an overloaded curriculum and teachers who teach different subjects. Quite a number of the participants said that *"The educator is teaching different subjects and different grades. He is after the completion of the syllabus. There is minimal time for allowing learners to perform the practicals. The educator is focusing on the knowledge and content of the subject matter".* Another participant reiterated that he/she is *"overloaded with learning areas".*

9.14.5.4 Lack of media resources

Not only do participants lack resources to conduct demonstrations and practical investigations, they also do not have electronic media resources like internet, intranet, extranet, satellite broadcasters, audio/videotapes, interactive TVs, and CD-Roms. This problem was mentioned by participants who indicated that *"the school does not have the necessary resources i.e. projector, DVD, software for* *simulation and multimedia presentations"... "No video of experiments and no DVD's"... "Not in possession of relevant science DVDs and videos"... "DVDs and videos of experiments not available at school. The school can't afford them since it is a rural school found in a very poor community."... "school does not have a TV, DVD players"... "There is a serious want of such material. Efforts to obtain such, has been futile"... "Ek het nie internet in die klas tot my beskikking nie. Ek het 'n voorraad van ou video's, maar beperkte hoeveelheid of geen DVD's. Ek sal graag nuwe programme oor die sillabusinhoud will kry, die skool het egter nie geld om dit aan te koop nie."* This is an indication that most schools do not have multimedia resources, and in cases where there are resources, they are not enough.

9.14.5.5 Limited teaching time

Teaching time is a problem that causes teachers not to engage learners in strategies that promote scientific inquiry skills. According to the Learning Programme Guidelines for Physical Sciences (DoE, 2005b:8) as discussed in paragraph 7.10, teachers have about 38 weeks for teaching and learning per annum. However, teachers found this time to be inadequate to enable them to successfully implement OBA of Physical Sciences in FET Band. One participant emphasised this by stating that *"Teaching time is very short and with the kind of learners I have, they are very slow so more concentration or more focus is ensuring that they understand scientific concepts and are able to apply them to solve scientific knowledge".* Another participant wrote that *"Lack of time is reason. For using such strategies, at least 1 hr is needed. Single periods are not enough to carry out this (I have only one double period a week)".* Another participant also complained about limited teaching time by writing: *"TIME! Syllabus too long!"*

Other reasons provided by participants for not using, or inadequately using effective strategies to teach learners scientific inquiry skills ranged from personal reasons to learner variables. One participant indicated his/her reason as: *"We were not workshopped on simulations. I therefore have no idea what simulations on experiments are all about. I really did not do simulation in class or in the laboratory".* This statement indicates that some teachers were not exposed to, or experienced a lack of understanding about multimedia resources. Other participants placed the blame on learners by indicating that *"They (learners) are not equipped enough to work on their own".*

9.14.6 Reasons for not using practical methods (e.g. experiments) when assessing learners in Physical Sciences

Participants gave the following reasons for not using practical methods (experimentation) when they assess their learners in Physical Sciences:

9.14.6.1 Lack of resources

As indicated previously, a lack of teacher support materials in the OBA of Physical Sciences in the FET Band is the most prominent obstacle. Some of the participants said that *“The resources are not available at school”… “No enough apparatus chemicals expired”…… “Lack of chemicals and laboratory”.......”Do not have enough apparatus”….* One participant further indicated that *“Since there is no laboratory in our school, some of the laboratory equipments are unavailable and there is a problem of chemicals that are finished in as far as chemistry is concerned and in Physics esp. electricity the batteries have run out before we can use them …………..”.*

Marx et al. (2004:164) stress the importance of practical work as a vehicle to teach learners inquiry skills and say that it should take place in a highly resourced setting. Thus, a lack of resources in most schools is to the detriment of OBA of Physical Sciences in the FET Band. Learning and teaching support materials are distributed unevenly in schools, and black rural and township schools are usually the worst off. This statement is underlined by one of the participants who said that *“Rural schools seem to get less attention of the Department Officials especially subject specialists”.*

9.14.6.2 Overcrowded classes

Quite a number of the participants indicated that their Physical Sciences classrooms are overcrowded. Participants mentioned *“small classrooms with large number of learners in each class (overcrowding)”… “the school does not have enough space to do practical work with learners….”.* Another participant responded in capital letters that the *“LACK OF CLASSROOMS OR EMPTY ROOMS”* is the reason why he/she did not use practical assignments to assess learners in Physical Sciences. Physical classroom space has for decades been a real problem in schools, especially in black rural schools or township schools. When referring to this problem of overcrowding, Warnich and Wolhuter (2010:74) say that it is common knowledge that facilities such as chairs and desks, classrooms and laboratories are sorely lacking in the historically black rural and township schools and that about 42% of these schools are overcrowded. Warnich and Wolhuter (2010:74) also say (quoting Jansen, 1999a:13) that Spady (the father of OBE) during his visits to South Africa warned that OBE did not work in the United States and was unlikely to work in South Africa because of the sheer deprivation of physical resources. A shortage of classroom space indeed hampers the successful implementation of the curriculum.

9.14.6.3 Overloaded curriculum

As indicated previously, the participants said that the NCS was overloaded and that it prohibited teachers from using practical methods (e.g. experiments) when assessing learners in Physical Sciences. They found the work schedule to be overloaded with new content that is not easily understood by learners, and because of that it takes too long to complete. In this regard, participants commented as follows: *“Time!*

Syllabus too long and too difficult especially in grade 10 it takes a lot of time for learners to grasp the new work. Gap between grade 9 and grade 10 very big. If the learner thought in grade 9 he can do Physical Science it does not mean he actually can do it in grade 10". Another participant indicated that the *"work schedule for Physical Sciences are so congested and in most cases we rush to finish the work schedule and overlook practical work.* Another participant stated that *"Die nuwe syllabus is werklik te oorvol met nuwe teories (teoretiese) feite en kennis wat ons moet oordra. Ek dink werklik die werkinhoud moet verminder word, sodat ons weer die geleentheid het om basies konsepte en praktiese vaardighede behoorlik aan die leerders oor te dra en aan te leer soos in die verlede".* For these reasons, participants advised that the syllabus should be revised and attention should be paid to its coherence so that content treated in the lower grades prepares learners for the content presented in the higher grades.

9.14.6.4 Limited teaching time

Limited teaching time seemed to be one of the major reasons why participants did not use practical work for their assessments. Participants made the following comments in this regard:"*Less contact time i.e. A period takes 30 minutes, so I find it difficult to teach and do experiments at the same time. Even though I sometime use study time. I'm not alone who is seeing these learners at that time. We have study time-table where I sometimes see them after a week. We do have Saturday lessons of which I sometimes use them for practicals, the problem is that the learners don't call for them and I have to postpone to the school days/week days where they'll all be present".* Practical work usually needs some time and thorough planning, and teachers do not feel that they have enough time or support from other teachers. Some participants further indicated that *"Some of the experiments take time and the periods are not ……. Sometimes a teacher gets angry if learners come to his/her class late after a practical lesson. Even if you discuss before the lesson some feel you want to make your subject better. Most of the time the practical work & cleaning up can be done within an hour. Occasionally you need 5 or ten minutes extra and that discourages a person. The planning and preparation takes lots of time without assistance".* Others feel that there is no time at all to do practical work. They commented that *"Time to do practical work is limited, in actual fact, there is no time to do practical work…."* One HOD said that "*TIME, TIME, TIME. As H.O.D I am responsible for timetable which changes a lot because due to lack of Departmental policy, educators come and go as they wish and they do not give a quarter times notice".* This problem is exacerbated by the concomitant rationalisation and redeployment of teachers.

9.14.6.5 Lack of departmental support

The introduction of new subject content that is "difficult" to teach without the necessary departmental support and a lack of training in practical work is a worrying issue as a substantial number of the teachers who teach in the FET Band are either under-qualified or unqualified to teach Physical Sciences. According to Warnich (2008:4) the Department of Education has an important function to identify teachers' training needs and to address those needs. In-service training programmes such as workshops and short courses, serve as important development opportunities for teachers to equip themselves to interpret the curriculum and the assessment policy (Warnich, 2008:4). This need was mentioned by participants when they gave reasons for not using practical work to assess learners in Physical Sciences. One of them commented in capital letters that *"THE* DEPARTMENT DOES NOT PROVIDE SUPPORT IN TERMS OF WORKSHOPS, PARTICULARLY ON PRACTICALS AND PROVISION OF EQUIPMENTS AND CHEMICALS". It should be noted that in cases where teaching and learning support materials are available in schools, these are frequently not used due to participants' lack of knowledge or skills. In this regard some of the participants commented that *"The department has since supplied many equipments to schools, to operate some of these equipments teachers need to be work shopped. There have never been workshops on how to handle some new apparatus as a result they are gathering dust and turning into white elephants. This is the biggest weakness of the Department after spending millions on apparatus"*; and *"…. There are no manuals to operate some equipments, hence lack of departmental support".* A lack of departmental support, practical skills and a lack of understanding of science concepts underscore teachers' failure to optimally use resources at most schools (Muwanga-Zake (2001) as quoted by Warnich, (2008:72). This sentiment is underlined by one of the participants who indicated that the reason he/she does not use practical work to assess learners in Physical Sciences is *"My fear based on that I don't want to put life of the learners in danger, because they have good future ahead about science".* One wonders what good future in science the participant is referring to when he/she is depriving the learners of the opportunitt to develop scientific skills. One participant recommended that *"Workshops have to be perpertualy* (perpetually) *done by the department to enhance educator training because education is dynamic nowadays, i.e. changes now and then".*

9.14.7 How teachers usually asses learners' practical work

As explained in paragraph 6.4.4, there are various methods of collecting evidence of performance from learners. They include amongst others observation-based assessment, test-based assessment, and task-based assessment. Task-based assessment is mostly used for the practical component of the subject because it determines how learners put theory into practice. Although most participants did not exactly explain how they assess their learners' practical work because it is often difficult to separate methods of recording (given by most) from methods of assessing, most of the participants who responded to this sub-section indicated that they do not use a single method of assessment, but rather a mixture of assessments.

9.14.7.1 Using rubrics and/or memorandum

Of the 52 participants who responded to item 4B5 in this sub-section, 36 participants indicated that they assess their learners' practical work in Physical Sciences by using rubrics. According to the NCS (DoE, 2003b:60) rubrics are a combination of rating codes and descriptions of standards. They consist of a hierarchy of standards with benchmarks that describe the range of acceptable performance in each code Band. Most importantly, teachers should know exactly what is required by the outcomes [i.e. which outcomes are being targeted? which Assessment Standards are targeted by the task? What kind of evidence should be collected? What are the different parts of the performance that will be assessed? Etc. (see paragraph 6.4)]. When responding to this sub-section some of the participants said:

"By making use of a RUBRIC which clearly states that a learner is going to get a mark when he/she did these and no mark when these is not done. The RUBRIC clearly states the teacher expectations and it is given to learner beforehand for him/her to be able to see what is it that is expected from him/her"…"USE A RUBRIC IN ORDER TO ACCOMMODATE ALL THE SKILLS NECESSARY FOR PHYSICAL SCIENCES"……"Use rubric in which I assess the following

Are learners able to – plan (1) state the question

(2) hypothesis

(3) aim

- Design (1) list the apparatus

(2) outline procedure

- Execute practical

(1) follow procedure and do practical

(2) observe and record results

(3) analyse results

(4) Drew conclusion".

"I normally usually use the rubrics it is:-

1) Rubric for conducting experiment where I focus on the skills of handling the apparatus and using them appropriately, the skill of following instruction properly and making good observations, and also focus on whether learners are able to understand or interpret what is happening or interpreting results from observations made.

2) Secondly it is the rubric for written report of experiment which assess the skills of learners of reporting the results and whether they are able to conclude base on results".

"Learners are given rubric which is going to help them to know exactly on what are they going to be assessed".

"Use a rubric to assess the practical work".

"Practical investigations are assessed with rubricks".

"By using memo and rubrics".

"I give them rubric and explain it,

While they are busy with the experiment, I assess certain skills, such as handling of apparatus. Graphs, tables and other information are assessed after they have completed".

"By using rubric and by observing them while they perform.

"RUBRIC, MEMO".

" I explain to them some concepts pertaining to the chapter or the experiment and what they must do, Assessment Standard. I then ask them to collect the apparatus and write report:

i.e. Investigative question and hypothesis

Write down the apparatus & chemicals to be used.

Write the method and observations

Write variable (if applicable) and then conclusion.

I also design a rubric and explain it to the learners so that they know what is expected and what to do, even a memorandum if there are questions asked".

"Using rubric for assessing: - Planning

Hypothesis

Method

Research

Graph, Tables

Conclusion"

"Use rubrics for each individual learner

Asses them while they are busy with the experiment as well as the report they hand in".

As indicated above, most participants used rubrics, rubrics and memorandums, or memorandums to capture data collected during assessment so that it can be logically analysed and recorded and reported in an accurate and understandable way.

It should be understood that there are numerous methods of collecting assessment evidence (i.e. observation-based assessments, test-based assessments and task-based assessments). At most, teachers use task-based assessments when assessing learners' practical work in Physical Sciences. The task-based assessment method is aimed at showing whether learners can apply the skills and knowledge they have learned in unfamiliar contexts or in contexts outside of the classroom. Performance assessments also cover the practical components of the subject by determining how learners put theory into practice. The criteria, standards or rules by which the task is assessed are described in rubrics or task checklists/memorandums or both to enable the teacher to use professional judgement to assess each learner's performance (DoE, 2003b:59).

9.14.7.2 Worksheets

There are participants who indicated that they use worksheets to assess learners' practical work. Experimental worksheets are guides that take the learners step by step through the practical procedure. It is sometimes referred to as a "cookbook" that makes use of performance, observation and the elaboration/explanation (POE) procedure. The learner starts by reading the instructions, then follows the instructions by performing the activity or action, and then observes what happens. Afterwards the learner elaborates/explains what has happened. During the process, the teacher makes use of task-based assessment as explained. Task-based assessment can be applied alone or can be coupled with observation-based assessment like in the case of a participant who indicated that: "*I assess my learners' practical work by means of a worksheet that I have complete during the practical. I also spend a lot of time going around to their groups while they are busy to see if all learners in the group is involved, and also to address any questions that may arise while the learners are busy. It is also very important for me not to immediately answer the learners' questions, but to help them change their point of perception".*

Sometimes this procedure can take the form of group-assessment, where learners are given the opportunity to discuss the activity while performing the practical work. This kind of inquiry is called cooperative learning and one of the participants indicated that when he/she assesses learners' practical work, *"Learners are put into small groups of 5, with each provided with a work sheet; with clearly defined steps".* This strategy is usually applied by most teachers because they can access ready-made worksheets available from most textbooks. One participant said that he/she *"Give learners practicals questionnaires or tutorial for the preparation of the practicals.*

- with valid instruction and intense supervision learner perform their experiment with help of mobile lab from University of Pretoria".

Another participant also reiterated that he/she *"Provide learners with work sheets all the materials and then monitor for safety reasons, most practicals are done in groups".*

9.14.7.3 Observations and/or using a report form

Due to environmental constraints that teachers find themselves in, most of the teachers make use of demonstrations. As indicated above, most schools do not have the required resources. Sometimes they are there, but have become dysfunctional, while at other times the appropriate functioning resources are available, but teachers refrain from using them to their full potential. Participants voiced their frustrations when they indicated that chemicals have expired and equipment is not available and teachers and learners have to travel to neighbouring schools or wait for a mobile laboratory. Opportunities for learners to conduct experiments by themselves in a group are severely limited by the fact that most schools do not have the required apparatus. For that reason, teachers develop their own practical worksheets or draw more widely from other curriculum support texts. As one participant indicated: "*Mostly demonstration – where learners respond to questions".*

Experiments – guided questions based on an experiment". Another one elaborated further that *"I demonstrate the practical while explaining and then hand over to them to do the experiment on their own while they are also recording results on their recording sheet".*

Some teachers conduct demonstrations and ask learners to write a report on what they have observed. The report is then marked by the teacher using either a memorandum or rubric, as indicated by the participants below:

"I explain to them some concepts pertaining to the chapter or the experiment and what they must do, Assessment Standard. I then ask them to collect the apparatus and write report:

i.e. Investigative question and hypothesis

Write down the apparatus & chemicals to be used.

Write the method and observations

Write variable (if applicable) and then conclusion.

I also design a rubric and explain it to the learners so that they know what is expected and what to do, even a memorandum if there are questions asked".

"*Observe their practical work – use rubrics – mark their report on the practical work – use rubrics".*

"Give them instruction to follow and then observe as they are in action".

"They are given questions and answers i.o.w. a worksheet.

-when the demonstration is done some more questions is asked to the group.

-The learners are also asked to work in groups e.g. build an electric motor with the kit provided".

9.14.8 Participants' comments about moderation of practical work by Subject Specialists

What follows are the participants' comments about the moderation of practical work by subject advisors or subject specialists. When responding to item 5B5 in this sub-section, some participants responded rather negatively about the practice of moderation. As practical work refers to learners being given the opportunity to practice and develop various process skills, subject advisors have to make sure that the marks allocated by teachers to learners' practical work tasks are fair and of the same standard. The participants found this process to either be "a good one", "a fair one", "developmental"; "not necessary"; or "performed by incompetent subject advisors". The discussion of the responses to this item will be categorised as positive responses and negative responses. Not all responses will be discussed, but the participants responses to this sub-section (Sub-section B5) can be found in Appendix B.

The following is what some of the participants said about the moderation of practical work by subject advisors/specialists:

9.14.8.1 Positive responses about the moderation of practical work

Most participants found the external moderation of practical work by subject advisors to be very good, in line with the NCS and developmental in nature. This was evident when one participant indicated that "*If I have to rate subject specialist moderation of practical work, I would say excellent!!! Their moderation has helped me a great deal!!!!!"* Another participant added to that by saying, *"Goed"* to the work of the subject advisors. Other participants continued to say, "*My subject specialist moderates the practical work very well and he even gives suggestions on how to deal with the matter". "It* (subject advisor*) is valuable asset for the educator, because it* (subject advisor) *helps to identify problem areas for your own improvement"*. One participant whose comment cannot go by unnoticed said: "EXCELLENT WORK, DONE BY SUBJECT SPECIALISTS".

It should be noted that what the subject advisors are moderating is not necessarily the practical work itself, as supported by one participant who said: "*They usually assess marks not necessarily whether the practical work was done correctly"*, another one added that *"SUBJECT SPECIALIST ONLY*

COUNT THE MARKS ALLOCATED TO CHECK ONLY IF THE MARKS TALLY WITH THE MARK SHEET". Another participants experienced it differently: "*My subject specialist moderates the practical work very well and he even gives suggestions on how to deal with the matter*". This is supported by another who said, "*They do a thorough job by carefully checking if learners conducted the experiment on their own and were able to report on the experiment"*… "*IT IS UP TO STANDARD"*, said one participant, suggesting that the moderation of practical work by the subject advisor/specialist is fair and up to standard. According to another participant, one thing that enhances the quality of moderation is the fact that "*Subject specialist do moderate practicals and they take a closer look at the rubric and marks allocated to learners. The practical activity is then discussed and where possible they (specialists) together with educators come up with other possible ways of doing that practical. What is interesting is that the APO educators agree on common practicals per grade. Practicals are not just done but they are done per agreement".*

Another participant said that not only do subject advisors moderate the practical work during their visits to APOs, but "*They are supportive and also assist us educators in terms of implementing cass* (CASS*) correctly and to the fullest".*

The above positive comments indicate that some subject advisors use moderation productively to provide departmental support in terms of the implementation of OBA of Physical Sciences in the FET Band.

9.14.8.2 Negative responses about the moderation of practical work

Even though some participants commented that the work of the subject advisors with regard to the moderation of practical work was excellent or fair, there were those who felt that "*Clear instructions about what a investigation should entail and what a research project should be like must be given to National. I am a Provincial SBA moderator and most of the investigations that I had seen cannot even pass as practical work. Only when everybody knows what is expected can moderation be meaningful".* This comment implies that although subject advisors are trying their best, teachers and some subject specialists are not yet conversant and confident to implement OBA of Physical Sciences in FET Band. This statement is underlined by another participant who said that "*Some subject specialization* (specialists) *does not have clear understanding of certain practicals and at the end they create confusion due to their adherence to their regid* (rigid) *moderation instrument*. One of the participants said that *"We have very few subject specialist because in many instances we* *have the same understand of the subject and technical know how to improve approaches to the teaching of the subject".* This can be a good thing as long as the specialists can come up with alternatives in problematic cases.

Even though some subject advisors are doing their best, they only meet with teachers once per year during the CASS moderation, which is towards the end of the year. Teachers fail to realise the importance of having subject advisors/specialists if they are not more readily at their disposal. "*It is done once a year",……"Sometimes it is not up to scratch because it is late to send the teacher back to do another practical"…." We don't have a practical moderation per year. We only have quarterly CASS moderation".* Although this is a noble practice, it is not extended to all the grades in the FET Band, but *"PRACTICAL WORK IS ONLY MODERATED IN GRADE TWELVE (CASS) DURING MODERATION OF CASS MARKS"*. Maybe the reason for this is the fact that "*We have very few subject specialist……..."* (as expressed by one participant).

Other comments were*: "It would have been better if this process is spread across the FET Band". "The worrying factor with the present practice is that, since moderation of practical work/CASS is done once a year",* and *"PRACTICAL WORK IS ONLY MODERATED IN GRADE TWELVE",* and *"when does the subject advisor/specialist meet with the teachers or HOD's of other grades?"*

9.14.8.3 Participants' suggestions with regard to the moderation of practical work

Some of the participants came up with proposals with regard to the assessment of practical work such as: *"Meetings must be called in January so that all teachers know exactly what is expected from them*" and *"This can be done twice per term"*. These suggestions will promote the relationship between teachers and subject specialists, and negative comments such as the following can be prevented, "*Subject specialists never satisfied by the rubrics, unless they must provide their own. Even if we are using the rubrics provided by the provincial CASS document, still complaints are their solution, department must give us the clear guideline about each term's practicals and rubrics. As a science teacher, I like experiments than practical investigation*".

Another participant suggested that *"SPECIALIST SHOULD ALSO USE THE TOOL USED BY EDUCATORS"*, because of the disparities amongst the schools. Another participant proposed, *"I* *personally feel that moderation of practical work by specialists should differ according to the type of school they moderate. The school which do not have a laboratory with all the equipments is not the same as the one which do not even have a lab. It becomes very difficult for the teacher to do the experiments if the school does not have necessary equipments". If the teacher improvise, then the specialists doing moderation, they usually question what is been done by the teacher. They usually come there as fault finders but not to assist so they are making our lives very difficult. They will be questioning your assessment and they are never satisfied but not all the subject specialists are behaving like that".*

9.14.9 Participants' general comments about the OBA of Physical Sciences in the FET Band

When OBA was introduced in the FET Band in 2008, it assumed a new way of assessment practice that differs in nature and methodology from traditional input-driven assessment. It emphasises the end result of learning, where assessment must establish whether educational outcomes have been reached by learners who need to demonstrate acquired knowledge, skills and values (Warnich, 2010:83). The focus of assessment moved from the memorisation of mainly facts to the assessment of critical thinking, creativity, problem-solving strategies, skills and values (Vermeulen, 2000:74) (as quoted by Warnich, 2010:83). Related to this statement, the participants gave the following positive and negative general comments about the OBA of Physical Sciences in the FET Band.

9.14.9.1 Positive comments

Of the possible 72 participants, 40 made positive comments with regard to their experiences of OBA of Physical Sciences in the FET Band. Some of the participants said that the OBA of Physical Science is good, by making statements such as: *"OBA is good since it helps to prepare learners for the future by providing them skills that will help them in the scientific environment. It allows learners with different opportunities (assessment opportunities) to pass their studies. It also helps the educator to understand the weaknesses and strength of his/her learner. It also allows learners to make individual assessment to understand their weakness and strength".* Others commented that: *"It is a yardstick that can be used to measure how far learners are, their weaknesses and the idea of performance at the end of the year*". Another comment was: "*Learners are highly involved. They work on their own at their own pace. It promotes mutual cooperation*". Another participant said that *"I <u>MAT</u> THE GOOD ASSESSMENT THAT CAN HELP TO PUT ON PHYSICAL SCIENCE IN FET ON THE GOOD TRACK AMONG OUR LEARNER'S WORK; ALSO IN TEACHING".*

9.14.9.2 Negative comments

OBA is a multifaceted and complex process that has implications for the way in which the assessment process is planned. For various reasons, the role of planning for the assessment process seems to be something that has not yet come into its full right in South Africa as it has been done in the international arena (Lombard, 2010:31). A lack of resources, insufficient training in the implementation of OBA, incompetent trainers, an excessive workload, an overloaded curriculum, lack of departmental support and other factors such a complex curriculum, lack of coherence in the curriculum and incompetent learners are factors that caused participants to experience OBA of Physical Sciences in the FET Band negatively.

9.14.9.2.1 OBA causes a work overload

Some of the participants were of the opinion that the curriculum of Physical Sciences in the FET Band is overloaded and that there is too much content to be covered within a too short space of time, resulting in an excessive workload. The number of assessment tasks that must be completed for the purposes of CASS is another negative factor. Some of the participants responded that *"Educators feel pressurized because it needs a lot of time but at the same time work schedule has to be completed". "Practical work must be done after school hours – sometimes difficult because of sport activities". "….. It involves so much time and paperwork which reduces contact time"*.

9.14.9.2.2 Lack of resources to assess adequately

Physical Sciences is a subject that needs to be taught within a resourced environment because teachers need to close the gap between what learners know and what should be practically applied. Teachers must conduct experiments, engage learners in practical work and give them opportunity to explore so that they can apply their knowledge. Not all schools are suitably equipped for the effective implementation of OBA of Physical Sciences in the FET. Various participants mentioned that there is *"No sufficient resources in many schools*". Other participants said that "*It is a disadvantage to those learners who do not have laboratories, equipments and libraries. It becomes difficult for those to do practical work, as for research projects, they do not have the access to some important information which can only be accessed a library e.g. Internet, etc"*. Another participants mentioned that "*Constructivism is not possible within limited resources e.g."*. The problem of limited resources was the most worrying factor for most of the participants.

9.14.9.2.3 Overloaded curriculum in terms of content

When OBE was introduced into the FET Band in 2007, new concepts in Physical Sciences were introduced and others were moved from one grade to another within the FET Band. This resulted in a situation where significant amounts of work had to be covered per year in certain grades. One frustrated participant commented that *"Syllabus too long, don't cater for electricians and other technicians learners don't want to take the subject because of the difficult. Other subjects were made more easier for instance he can easily obtain a distinction in languages, business studies, life sciences, etc. but definitely NOT in physical sciences*". Another participant who felt the same reiterated that "*Syllabus too full and extensive – no time to help the children with difficulties. For grade 12 the percentage composition faulty. The research assignment counts more than an exam that test knowledge and insight? How does that work"*?

Even Afrikaans speaking teachers who teach the subject in their mother tongue to Afrikaans speaking learners had this to say about the OBA of Physical Sciences; " *Die sillabus is te oorvol. Jy kry glad nie kans om basiese konsepte in te oefen by die leerders nie. Hulle weet op die ou end te min van enigiets, want hulle verloor moed. 3 verpligte projekte is te veel per jaar en dit vat baie tyd vir leerders om navorsing te doen, waar hul eerder kon leer en vrae kan uitwerk*".

Another participant said that "*ASSESSMENT IS NOT EFFECTIVE BECAUSE OF THE RUSH TO COMPLETE THE WORK SCHEDULE AS EXPECTED. FOR EXAMPLE GRADE 11 WORKSCHEDULE IS JUST TOO LONG TO BE COMPLETED IN ONE YEAR AND LEAVES NO ROOM FOR EFFECTIVE ASSESSMENT*".

For most teachers, the curriculum is not easy to complete within the scheduled time as "*It take a long time and it impacts on the completion of the work schedule and pace setters. Weak learners hide behind learners who are gifted. It does not give the true reflection of the actual marks obtained by the learners".*

Most participants felt that *"Too much is expected in very little time in terms of content to be covered and mastered by the learners".*

9.14.9.2.4 Lack of departmental support to assess effectively

Warnich (2008) stated that it is the responsibility of the Department to see to it that before the curriculum is implemented, the teachers are well and thoroughly trained on the implementation of the new syllabus. Follow up workshops should be conducted to ensure effective implementation. Yet, some participants made comments such as "*Assessment tool and how to design a practical investigation is still a nightmare to a certain extent",* Other participants complained that *"Practicals are to be done but the Department does not see to it that schools have necessary and relevant resources for those required practicals"*. Another participant complained that although teachers have done their utmost to implement the new curriculum without relevant resources, "*The quality of work is not been checked"*, by the department.

9.14.9.2.5 Lack of training/inadequate training to assess effectively

A number of participants stated that the failure to successfully implement the OBA of Physical Sciences in the FET Band can be ascribed to the fact that the department did not provide adequate training. One participant summarised the concerns of the other teachers by stating that "*Not enough preparations was done by those in power or those who understand it better*".

9.14.9.2.6 Lack of coherence of concepts

Some participants were of the opinion that the curriculum does not prepare learners for the work that will be covered in the next grade. The following statement captures their opinions: "*Lack of coherent of concepts. Concepts that are asked in Grade 11 are not in Grade 12 at all which implies to wide concepts for the learner that understanding is difficult*".

9.14.9.2.7 The NCS is very difficult to implement and to understand

Despite the fact that most participants possessed the NSC document and attended training in OBE and OBA, some still experienced the OBA of Physical Sciences in the FET Band to be complicated and difficult to implement. One participant said that the curriculum is "*Very difficult to implement*". Not only is the assessment difficult for teachers, learners also experience difficulties to follow exactly what the frustrated teachers are trying to teach and assess.

9.14.9.2.8 Learners' abilities to master subject content knowledge

Some of the participants indicated that "*Most of our learners do not understand method of questioning as they can't read well*". Other participant lamented that "*Some of the questions are way above the comprehension of our learner (black) in disadvantaged school because of language barrier-";* "*Weaker learners suffer with the work. If they are in the same group as stronger learners they just copy the work*".

One participant stated that "*It gives everybody the opportunity to pass including those who are not doing enough or even deserving to pass*". This affects the general perception of learners towards their school work because "*Learners are only interested and puts effort in ONLY the assessment that counts for their term/year mark, i.e. the prescribed ones. Other (informal) NOT part of CASS do not really reflect learners true potential, because they do not prepare for it*".

9.14.9.3 Suggestions to improve the OBA of Physical Sciences in the FET Band

The following are some of the participants' suggestions about what can be done to improve the OBA of Physical Sciences in the FET Band:

9.14.9.3.1 Allow more teaching time

Participants complained about learners from the General Education and Training Band (GET) who arrive ill prepared for the academic demands of FET Band. One participant commented that: *"I am of the opinion that learners are struggling in the F.E.T. phase because they do not spend enough time mastering the basics of Physical Science during the 8^{th} and 9^{th} grades.*" For that and other reasons, one participant suggested that: "*More time be allocated to P-science like Maths to enable educator to have enough time to perform practicals. Laboratory educator also be introduced and work in laboratory only to perform practicals for learners.*"

9.14.9.3.2 Reduce the administrative workload

It is not only the assessments that adds to the participants' workload, but also the careful recording of each learner's mark for each of the assessment tasks and the calculation of each final CASS mark that are seen as the last straw to break the proverbial camel's back. When complaining about this, one participant had this to say: *"Admin "pink" files with requirements that keeps the teachers so busy* *to window dress in order to keep Umalusi happy is taking up valuable teaching time."* According to this participant, it is not all that necessary to record learners' portfolio marks.

For that reason, one participant suggested that the department should: *"... decrease paperwork or paper work to be done by department and teachers to teach only. Assistant teachers to be employed by the department so that they can take care of the paper work*. Another participant suggested that: *More teachers should be hired. - one teacher should be responsible for only one grade per learning area for thorough preparations*. *It must be practiced thoroughly from lower classes.*

According to these participants, it seems as if most schools are understaffed, as most teachers teach more than one class to different grades. That is why they suggested that: "*More qualified educators (for Physical Sciences) per school. When you must teach P.S. to four different grades you want to run away*!!"

9.14.9.3.3 Provide more resources

For the effective implementation of OBA of Physical Sciences in the FET, some of the participants suggested that the department can enhance it by "*Making the resources available in all schools (where physics is offered by learners)" ..... "more materials to be provided," ……"More resources can be given to schools. The department can provide everything to the schools."*

9.14.9.3.4 Streamline the curriculum and reduce overloaded

Most participants experience a curriculum overload, so the following suggestions were made: "*The curriculum especially in grade 11 Physical Science is too large and there is no time to explain everything in details. Some topics should be of self-study*." Furthermore "*Those in the Physical Sciences stream must be give a chance to offload some subjects in grade 10 and specialize in Physics as pure, Chemistry as pure and mathematics in grade 11 and 12. This will ensure more time for them to complement well advanced practicals together with detailed theory. Chemistry and Physics should be 2 different subjects*."

The participants went further to suggest that because they find the syllabus overloaded, the department should "*skaal asb die totale hoeveelheid werk af, beperk die projekte vir CASS tot slegs een projek so dat ons meer informeel daagliks praktiese ondersoek en demonstrasies kan doen*.".

Participants also suggested that the department should *"Remove common tasks like June exam – gives unnecessary pressure to learners and educators,"*. This means that June examinations run over four to five weeks to accommodate all the NSC subjects offered in a province and for that reason considerable teaching time is lost in June and August.

Another participant suggested that the department should look at the *"reduction in the number of content subjects to three so that learners can at least specialize and be more focused on a few things, when energy is spread over a number of subjects, understanding of concepts becomes limited since things are generalized so that the syllabus be completed."* It should be noted that *"Deeper analysis and understanding of concept needs time and focus and practice at the same time*."

9.14.9.3.5 Enhance departmental support

It remains the task of the department to train teachers before implementing a curriculum change, so it is a completely fair for the participants to suggest that: *"TEACHERS MUST BE WORKSHOP THOUROUGHLY AND ALSO BE APPLIED THOROUGHLY." … "Workshops to be conducted every term to accommodate newly appointed educators;…. "practical investigations to be designed by the Province (Specialists) and provided to school to ensure a required standard in all the schools."…. "they suppose to request problems that encountered on physical science in various school; and then make workshop in order to resolve those common difficulties encountered by various educators." …"FROM EXAMINERS REPORT, TRAINING CAN BE CONDUCTED IN ORDER TO ADDRESS THE SHORT COMINGS AND IMPROVE THE SUBJECT KNOWLEDGE OF EDUCATORS." ……" More practical workshops and seminars." …."Teacher training by competent facilitators." ……"Provide more resources."….." Familiarise the educators with the system (OBA)." ….. "Provide training for implementation of projects, investigations, and practical research."*

9.14.9.3.6 Improve training

Participants experienced training as insufficient, so they suggest that the Department should: "*Make this training of OBA in every quarter or term. Make sure that every educator is well trained about OBA."* The implication is that the educational authorities must be prepared to invest in the continuous professional development of teachers. The ideal as suggested by Reyneke, (2003:145) would be for teachers to be assisted by the subject advisors in the implementation process. If such a person cannot render continuous assistance, teachers must be given guidance in planning and implementing the initiative. A platform should be created for teachers to reflect on and share their experience with other teachers of Physical Sciences as things develop. Teachers can then advise on training work for others in the future.

9.14.9.3.7 Improve coherence of concepts

Because some participants experienced an inconsistency between the curriculum and the content, the following suggestion was made:

"*Structure the content with practical activities and according to the exam guidelines – that everything is studied in the hope to meet it in Gr 11." ....*

Another problematic transition point that compromises curriculum coherence is between the GET and the FET Bands. Transition between these Bands is difficult for both learners and teachers. The lack of articulation pertains centrally to the shift from integrated learning areas in the GET, to discipline-based school subjects in the FET. This shift raises issues of the breadth and depth of coverage at the two levels. Participants reiterated that "*I am of the opinion that learners are struggling in the F.E.T. phase because they do not spend enough time mastering the basics of Physical Science during the 8th and 9th grades."*

Another participant went further to propose that the Department should *"Konsentreer ook op die basiese voordighede wat hul in Fisika en Chemie nodig het in gr 10 – 12, wanneer die leerinhoud van die junior fases beplan word."*

One participant stated that the Department should *"Change the promotion criteria in the GET Band because it is the one that is failing the grade 10's when they get to FET. Back to basics PLEASE!!!*

9.14.9.3.8 Simplify the implementation

No support materials such as assessment tools were available at the training sessions. The participants consequently felt that: *"Programme of Assessment must have pre-designed lesson practical investigations i.e. per core knowledge area." "..... Lesson plans be "readymade" and correlate with the work schedule though we are told to plan according to the environment yet examiners* *do not consider the environment factor …….” “…..We prefer one prescribed textbook especially for the learners.” “…….We must have a stable policy that is not revised timeously (meaning over and over).” “……The recording sheets must be revised to cater for tasks suggested above.*

Participants who were prepared to use alternative assessments strategies had to design their own assessment tools based on their interpretation of Assessment Standards. Thus, individual teachers designing their own assessment rubrics or marking guidelines could cause a variation in the scoring of assessment tasks among teachers. Because of that one participant suggested that: *“Let each prescribed practical investigation have its prescribed rubric with the memo included if possible.”*

In general, teachers found the Assessment Standards to be too generic and unclear in terms of what should be assessed and how it should be assessed. This has led to varied and inconsistent assessment practices amongst schools, districts, and provinces.

With regard to the compilation of year marks one of the participants made the following remarks: *“The Cass mark is compiled through the year and then amounts to 25% of the final mark and the exam 75%. That percentage must be carried the same way through the whole year when reporting per term. E.g. The first term practical work amounts to 80% of the report card mark and Tests 20% etc. At the end of the year this compiled mark is related to exam mark. Only the top candidates will correlate. This produces a problem for averages etc*.”

9.14.9.3.9 Allow more time for learner to master content knowledge and basic concepts

Most participants complained about the learners’ content knowledge and suggested that they should “*Expose learners to more content, like previously (old syllabus), more work was done*.” Another participant said that “*the DoE must involve different stakeholders who are in Science field to visit schools in order to arouse learners’ interest in science and also develop educators.*

Most learners are promoted to the next grade even before they could master the basics of Physical Sciences, so one participant suggested that “*Laat genoeg tyd toe om basiese vaardighede vir leerders in te oefen*. The participant furthermore suggested that “*Die vrae moet voorsiening maak vir sterk leerders asook vir die leerder wat sukkel of implimenteer asb weer ‘n HG en SG fase, sommige werk is werklik te moelik vir die gemiddelde leerder om op skool te verwerk.”*

9.15 SUMMARY OF THE FINDINGS EMANATING FROM THE QUALITATIVE INVESTIGATION (UNSTRUCTURED ITEMS IN SECTION B OF THE QUESTIONNAIRE)

On the basis of the participants' responses to the unstructured (Open-ended) items of Section B of the questionnaire, the following became apparent:

- A substantial number of participants were not satisfied with the standard of the OBA training they received because of the following:
  - Not enough time was spent on training
  - Training was conducted by incompetent trainers
  - The training was too theoretical in nature and lacked practical application value

- Even though most of the participants indicated that they felt confident to implement OBA, the following factors contributed to a lack of confidence among other participants:
  - Inadequate training in OBA
  - Incompetent trainers
  - A lack of practical application value of the training

- Some of the participants found the NCS document difficult to understand and complained that it contained unclear guidelines, and they cited the following reasons:
  - Documents are complicated and confusing
  - The documents implied a work overload
  - The curriculum is too full
  - Some of the content is irrelevant to real-life situations

- Some of the participants did not instruct learners to conduct experiments and practical work because:
  - Resources are lacking
  - Participants are inadequately trained to conduct experiments or did not receive any training in practical work at all
  - The workload does not allow time for experiments and practical work
- Some of the participants do not use effective strategies to teach scientific inquiry skills during practical work due to:
  - A lack of resources
  - Overcrowded classes
  - The overloaded curriculum
  - Limited teaching time
  - A lack of media resources

- Some participants are prohibited from using practical methods when assessing their learners due to:
  - A lack of resources
  - Overcrowded classes
  - The overloaded curriculum
  - Limited teaching time
  - A lack of departmental support

- Some participants mainly use the following methods to assess their learners' practical work:
  - Rubrics
  - Memoranda
  - Worksheets
  - Demonstrations
  - Reports

- Some participants found the moderation of practical work of learners to be:
  - Good
  - In line with guidelines of the NCS
  - Developmental in nature
  - Informative as it used as an extension to give departmental support

- Despite being a worthy exercise, some of the participants indicated that the moderation of practical work by subject advisors is:
  - A superficial process
  - Restricted to grade 12 only
  - Not practiced in other regions of the province
  - Confusing as the participants do not know what they are supposed to asses
  - Conducted by incompetent subject advisors
  - A process during which subject advisors only count the marks allocated to learners
  - Inappropriate in terms of its timing
- Some of the participants proposed the following to improve the moderation of practical work by subject advisors:
  - Workshops should be held at the beginning of the year to plan a schedule for the year and where training in relation to activities, experiments and practical work can be given
  - Regional, provincial and national tools for moderation must be aligned
  - Different criteria for moderation at urban and rural schools should be used
  - Teachers' inputs and improvisation should be acknowledged and the necessary departmental support should be given.

- Some of the participants made the following positive comments about the OBA of Physical Sciences in FET Band:
    - It is of a high standard
    - It prepares learners for the future
    - It provides learners with different learning opportunities
    - It is more learner centred
    - It promotes cooperative learning
- Some of the participants' negative comments about the OBA of Physical Sciences in FET Band were:
    - It causes an excessive workload
    - Lack of resources hinders its implementation
    - Difficult to implement due to an overloaded curriculum
    - Lack of departmental support makes implementation difficult
    - Lack of training and insufficient training are obstacles in the implementation
    - Lack of coherence of content is an obstacle in the way of implementation
    - Learners' lack of content knowledge causes excessive teaching time and allows very little time for assessment

- The participants made the following suggestions with regard to the effective implementation of OBA of Physical Sciences in the FET Band:

    - Natural Sciences and Physical Sciences must be allocated more teaching time
    - Assistant teachers must be appointed to deal with the recording of marks and other administrative work
    - More teachers should be employed
    - Resources must be made available in all schools that offer Physical Sciences
    - Chemistry and Physics should be made independent subjects
    - Projects should be limited to one project for CASS
    - Do away with common tasks such as the June examination
    - Reduce content subjects to three
    - Retraining of teachers in OBA should take place
    - Training must be provided by competent trainers
    - Continuous workshops, at least one every term, should be offered
    - The provincial education department should design practical investigation assessment tasks
    - Shortcomings indicated by examinations should be addressed during workshops
    - More practical workshops should be held

- Provide more training for the implementation of projects, investigations and practical research
- Content should be aligned to practical activities and examination guidelines
- There should be coherence of subject content between successive grades.
- The department should provide pre-designed lesson plans and plans for practical investigations
- Higher grade and Standard grade papers should be re-introduced

9.16 CONCLUSIONS BASED ON THE QUANTITATIVE AND QUALITATIVE FINDINGS OF THE EMPIRICAL RESEARCH

On the basis of the quantitative and qualitative findings of the research, the following conclusions were drawn:

9.16.1 Conclusions with regard to the primary research question

The primary research question as stated in paragraphs 1.2 and 8.2.1 of Chapters 1 and 8 respectively is:

- What assessment model can be proposed to facilitate the effective assessment of Physical Sciences in the FET Band by considering both the literature and the practical experiences of teachers in the North-West Province?

With regard to literature, chapters 2 – 7 of the literature study were used to explore the key concepts, fundamental principles and the philosophy underpinning OBE in order to reveal the elements of OBA of Physical Sciences in the FET Band.

On the basis of the findings, the following conclusions were drawn regarding the teachers' practical experiences with OBA of Physical in FET Band:

- Most participants received OBE training, but the duration of their training was relatively short.
- The Department of Education presented most of the training.
- In general, the quality of the training seemed to be satisfactory and most of the participants indicated that they are confident to implement OBA.
- Most of the participants are familiar with the different NCS documents and most of the NCS documents are available to all the teachers in their schools.
- Most of the participants have a personal copy of all these documents in their possession and find these documents easy to understand.

- Most of the participants are of the opinion that the documents contained clear guidelines for implementation.
- Most participants demonstrate their understanding of the NCS documents by responding positively to the questions related to the content of NSC.
- Most participants design their assessment activities with Learning Outcomes in mind.
- The majority of the participants design their assessment activities with the aim of attaining the aims of OBA.
- Most participants consider the principles of high quality of assessment when they plan their assessment activities.
- The majority of the participants do not support the non-structured informal assessment.
- Most participants agree that CASS contributes towards effective assessment of Physical Sciences in the FET Band.
- The majority of the participants find the OBA practice of assigning 25% to CASS and 75% to the summative assessment of Physical Sciences to be a fair practice.
- Most participants instruct their learners to conduct experiments only “once every term”.
- The majority of the participants use demonstration as their major strategy to teach learners scientific inquiry skills during practical work.
- The majority of the participants are less restricted by resources, training in practical work and departmental support from using practical work methods (e.g. experiments) when assessing learners in Physical Sciences.

Although most participants indicated that they received training in OBA, and are in possessions of the relevant NCS documents, some of their responses indicated a lack of practical implementation skills. It also transpired that some of the participants experienced a lack of resources and inadequate support from subject advisors in implementing OBA.

On the basis of the above results, one can state that the teachers in the North-West Province’s experiences of Outcomes-Based Assessment of Physical Sciences in the Further Education and Training Band in general were positive.

9.16.2 Conclusions with regard to the secondary research questions

The secondary research questions as formulated in paragraphs 1.2 and 8.2.2 of Chapters 1 and 8 are:

1. What are the challenges or obstacles that these teachers experience with OBA of Physical Sciences in the FET Band?
2. What sources/opportunities are there to support the OBA of Physical Sciences in the FET Band?

3. What role do biographical variables play in the OBA of Physical Sciences in the FET Band?
4. What assessment model can be implemented to facilitate the effective assessment of Physical Sciences in the FET Band?

On the basis of the findings, the following conclusions were drawn regarding the challenges or obstacles that these teachers experienced with OBA of Physical in FET Band:

- Some of them received inadequate training in OBA
- Some of them complained that the training was presented by incompetent trainers
- Some of them complained that the training lacked practical application value
- Some of the participants found the NCS document complicated and confusing and felt that it does not contain clear guidelines
- Some of the participants said that the curriculum is too full and that its contents are irrelevant to real-life situations
- Some participants do not instruct learners to conduct experiments and practical work because
  - Resources are lacking or absent
  - Participants were inadequately trained to conduct experiments or did not receive any training in practical work at all
  - The workload does not allow time for experiments and practical work
- Some of the participants do not use effective scientific strategies to teach scientific inquiry skills during practical work due to:
  - A lack of resources
  - Overcrowded classes
  - The overloaded curriculum
  - Limited availability of teaching time
  - Lack of media resources
- Some participants are prohibited from using practical methods when assessing their learners due to:
  - Lack of resources
  - Overcrowded classes
  - Overloaded curriculum
  - Limited teaching time
  - Lack of departmental support

With regard to the second secondary question, namely: *What opportunities are there to support the OBA of Physical Sciences in the FET Band,* the researcher came to the following conclusions:

- Most schools have running water and electricity

- Most schools have the apparatus to conduct practical work in Physical Sciences
- Most schools and teachers are in possession of NCS documents
- Most participants felt positive about the OBA of Physical Sciences
- Most regions have cooperative and efficient subject advisors
- Most participants are willing to implement OBA of Physical Sciences provided they receive adequate and efficient training and sustainable departmental support
- Most participants are experienced teachers and are adequately qualified to teach Physical Sciences in the FET Band.

With regard to the third secondary research question: *What role do teacher variables play in the OBA of Physical Sciences in FET Band*, the researcher came to the following conclusions:

- There is no relationship between the participants' gender and the different sub-factors that contribute towards the effective implementation of OBA of Physical Sciences in the FET Band;
- Middle aged participants were on average more competent to effectively implement the OBA of Physical Sciences in the FET Band, although their assessment activities were on average more teacher-centred than that of younger participants. They seem to lack in designing and implementing effective assessment activities that will benefit both the teacher and the learner.
- Younger participants were on average more inclined towards informal assessment tasks than their older counterparts. They seem to be more concerned about providing additional support to learners than the older participants;
- More experienced participants (16 years and more) were in general less likely to effectively implement OBA of Physical Sciences in the FET Band than less experienced participants.
- More experienced participants (16 years and more) were in general more unlikely to design OBA tasks than their less experienced counterparts. They seem to lack practical implementation skills of planning the OBA activities than the less experienced participants;
- The least experienced participants (6 to 10) were of the opinion that informal assessment tasks contributed towards effective assessment of Physical Sciences in the FET Band to a larger extent than their more experienced colleagues were. They seem to be more concerned about designing OBA activities that will provide learners with the opportunities to revisit certain sections of the curriculum, and to motivate and encourage learners;
- More experienced participants were on average more competent than less experienced participants about using different scientific investigations strategies to teach learners scientific inquiry skills in Physical Sciences in the FET Band;
- More experienced participants were on average less likely to be prohibited by a lack of resources and departmental support from effectively implementing OBA of Physical in the FET Band than the less experienced counterparts were. They seem to be more capable to design and implement assessment activities for practical work than the less experienced participants;

- Most experienced participants in teaching the subject were generally cognisant of the principles of high quality assessment and of the opinion that formal assessment tasks contributed more towards effective assessment of Physical Sciences;
- Participants with the lowest teaching qualifications were of the opinion that formal assessment tasks contributed more towards effective assessment of Physical Sciences in the FET Band schools, than their more qualified colleagues were;
- Participants with teaching degrees found that the lack of resources and departmental support prohibits them from using experimentation and practical work to assess their learner in Physical Sciences in the FET Band schools. They seem to lack practical implementation skills of practical work of Physical Sciences more so than the highly experienced participants;
- Participants with B-degrees plus teaching qualifications were on average less knowledgeable about practical work of Physical Sciences in the FET Band than their other colleagues;
- The highly qualified participants (Hons. or Masters' degrees plus teaching diploma) were more capable of using scientific investigation strategies to teach learners scientific inquiry skills than their colleagues with lesser qualifications;
- No relationship between the participants' position at school and the different sub-factors that contribute towards effective assessment of Physical Sciences in the FET Band were found to exist;
- No relationship between the participants' school location (urban/rural) and the factors that contribute towards effective assessment of Physical Sciences in FET Band were found;
- Participants with an average number of learners (31 – 40) in their Physical Sciences classes were more likely to effectively implement the OBA of Physical Sciences in FET Band than their colleagues with more learners in their classes;
- Participants with 21 – 30 learners in their Physical Sciences classes were more capable of using experimentation and practical work to effectively assess learners in Physical Sciences and were more unlikely to be prohibited by a lack of resources and departmental support from doing so than their colleagues with more learners in their classes;
- There was no relationship between the availability of laboratories at the participants schools and the sub-factors contributing towards effective assessment of Physical Sciences in FET Band;
- Participants without apparatus to do practical work (experimentation) found the lack of resources and departmental support to prohibit them from using practical methods to effectively assess their learners in Physical Sciences;

With regard to the fourth secondary research question, namely: *What assessment model/strategy can be implemented to facilitate the effective assessment of Physical Sciences in FET Band?* The researcher will propose a model in Chapter 10 that can be implemented to facilitate the effective OBA of Physical Sciences in the FET Band.

9.17 SUMMARY OF CHAPTER

In this chapter the results emanating from the empirical research were presented and discussed. Conclusions were presented based on the findings. In the next chapter a model for the assessment of Physical Sciences in the FET Band will be proposed.

CHAPTER 10

A MODEL FOR THE ASSESSMENT OF PHYSICAL SCIENCES IN THE FET BAND

10.1 INTRODUCTION

Based on the literature review and the findings emanating from the empirical study, the researcher designed a model for the assessment of Physical Sciences in the FET Band.

The empirical research revealed that most participants did receive training in OBA. They are in possession of all the NCS documents, which they find easy to understand and with clear guidelines. Yet, some participants' responses revealed that they lacked practical OBA implementation skills in the following areas:

- Planning assessment activities, where participants had to indicate the extent to which their assessment activities are planned to provide learners with the opportunity to:
    - acquire and develop practical, scientific and problem solving skills;
    - construct and apply scientific knowledge;
    - identify and critically evaluate the contested nature of science and its relationships to technology, society and the environment.
    - develop learners' knowledge, skills and values;
    - assess learners' strengths and weaknesses
    - provide additional support to learners;
    - revisit certain sections of the curriculum;
    - motivate and encourage learners.

- Designing and implementing effective learning strategies that will engage learners effectively;
- Designing and implementing effective assessment activities that will benefit both the teacher and the learner;
- Considering principles of high quality assessment (reliability, validity, and authenticity) when designing assessment activities;
- Utilizing different assessment strategies;
- Utilizing different assessment styles;
- Realising the benefits of CASS;
- Designing and implementing assessment activities for practical work, and
- Utilising strategies to teach learners inquiry skills.

10.2 Planning OBA activities

When planning assessment activities, teachers must take cognisance of the Assessment Standards (ASs) and Learning Outcomes (LOs) that should be demonstrated at the end of each lesson. For that reason, a model for the effective assessment of Physical Sciences in the FET Band is urgently needed. Such a model needs to start with the Learning Outcomes (LOs) and a selection of Assessment Standards that need to be broken down into clear guidelines for both teachers and learners. Learners should be aware of assessment criteria before any assessment activity can take place so that they can become active participants in the learning and assessment process.

When planning an effective assessment activity, teachers must decide which ASs fit a specific activity. The ASs from which teachers must select, are neatly grouped under specific LOs. Grouped as they are, it is still difficult for the teachers to make a meaningful selection of ASs that fit a specific teaching and learning situation. Furthermore, the ASs are often complex and do not focus on a single learning outcome (Reyneke, 2008:167).

Therefore, teachers first have to “unpack” the ASs in order for them to make a suitable selection and they have to keep good records of what has been taught and learned and what not.

In this study, teachers also indicated a need for a standard assessment tool because of assessment discrepancies that exist in schools, regions, districts and provinces. The NCS leaves much room for inconsistency because the assessment standard is set by teachers who find themselves at different schools in different parts of the province and in different socio-economic environments (Paragraph 9.14).

Designing and implementing effective learning strategies that can be aligned with the LOs and from which interesting, challenging and effective learning activities can be designed, is a challenge for most teachers.

Results emanating from the research also indicate that teaching, learning and assessment are not always learner-centred (refer to paragraphs 9.11.3; 9.11.4 and 9.11.14). Some teachers’ assessment activities are not designed to develop learners’ knowledge, skills and values, assess learners’ strengths and weaknesses, provide additional support to learners, revisit certain sections of the curriculum, or to motivate and encourage learners.

The research further indicates that the oldest and the most qualified teachers find the learner oriented CASS to contribute on average to a lesser extent towards effective assessment of Physical Sciences in the FET band (refer to paragraph 9.11.4 and 9.12). This implies that their assessment activities are to a considerable and large extent designed to benefit the teacher rather than the learners. Most teachers are more familiar with summative assessment tasks and find it difficult to accept unfamiliar types, methods, techniques and tools of assessment which, in an outcomes-based approach, are seen as the driving forces behind both teaching and learning.

In an attempt to resolve teachers' challenges with regard to OBA of Physical Sciences in the FET band, an assessment model that needs to align assessable learner tasks with LOs and ASs and must illustrate how different types, methods, techniques and tools of assessment should be used to assess tasks while providing for progression over the three years in the FET band. The model needs to illustrate how formative assessment tasks should be integrated into lessons on a systematic and continuous basis. It further needs to illustrate how formative assessment tasks that allow for early intervention should be implemented so that steady progress can be made. Once the learner had been exposed to various learning opportunities and has demonstrated evidence of performance in informal assessment tasks of a diagnostic or formative nature, the learner can be challenged with summative assessment tasks that will be formally assessed and for which the marks may be recorded as part of the learner's continuous assessment (CASS) mark.

It is important that these summative tasks flow naturally from teaching, learning and assessment. Not all the CASS tasks should be recorded and reported because the Subject Assessment Guidelines requires teachers to do so, but only for those tasks that serve a formative purpose.

In the following paragraphs the following aspects will be addressed:

- A learning programme for Physical Sciences in the FET band
- A basic lesson plan for teaching Physical Sciences in the FET Band
- Designing and implementing assessment activities for Physical Sciences in the FET Band.

10.3 A LEARNING PROGRAMME FOR PHYSICAL SCIENCES IN THE FET BAND

According to the Learning Programme Guidelines for Physical Sciences (DoE, 2005b:4-5), three phases of planning are recommended when designing the learning programme for Physical Sciences in the FET band. The first phase is developing a subject framework for the three grades to arrive at an understanding of the subject and the progression that needs to take place across the grades. The second phase is developing a year-long work schedule that indicates the sequence in which the content and context will be presented for the subject in that particular grade. Lastly, lesson plans must be designed that include learning, teaching and assessment activities that reflect the LOs and ASs.

The figure below indicates steps that are followed when designing a learning programme.

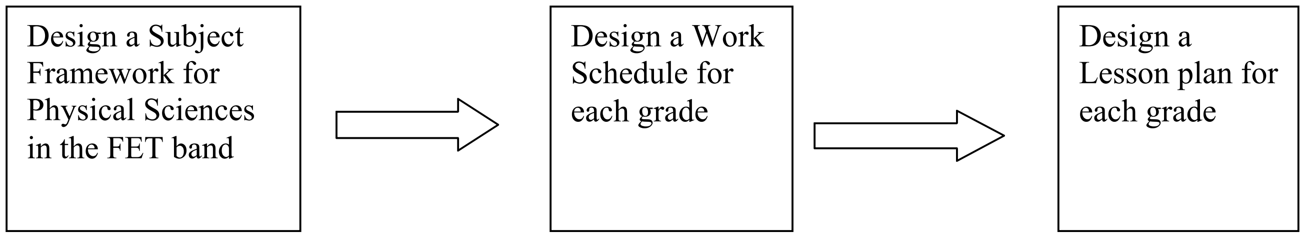


Figure 10.1: Steps in designing a Learning Programme for Physical Sciences in the FET Band

10.3.1 Designing a subject framework

The subject framework is a structured and systematic plan for the teaching, learning and assessment of Physical Sciences in the FET band. This plan is based on the scope of the subject to be covered in the three grades versus the time available to teach the subject over a year. The time refers to the number of weeks available for learners to attend classes, taking note of the school holidays, public holidays, days set aside for tests and examinations, and those set aside for extramural activities. Although time informs the subject framework, the emphasis at this stage is on the scope of the subject to be covered.

The scope of the subject Physical Sciences is informed by the following knowledge areas:

- Matter and Materials
- Chemical Systems
- Chemical Change
- Mechanics
- Waves, Sound and Light
- Electricity and Magnetism

During planning and selection of topics (which is already provided in the CAPS document), teachers should consider the level and interest of the learners, the location (urban, rural) of the school, integration with other subjects and the conceptual progression of the key knowledge, skills, values and attitudes of the LOs and ASs across the three grades. Understanding of the location plays an important role in planning the schedule because it influences learners' conceptual knowledge. Learners' pre-conceptions can be used by the teachers to plan their lessons. Learners' pre-conceptions enable the teacher to choose the conflicting situation/s that will help in discrediting or eradication of alternative conception in Physical Sciences.

Normally, one topic may run for a number of weeks, but the teacher needs to set the pace according to the attainment of the learning outcomes. The teacher should provide the necessary scaffolding, especially in the zone of proximal development, to help the learner to close the gap between what the learner could do alone and what can be done with help of someone knowledgeable. It does not help to move on to new outcomes when knowledge and skills of the previous outcomes have not been mastered successfully.

A three year assessment plan for Physical Sciences in the FET band should be included in the Subject Framework. Teachers need to consider types, methods, techniques and tools of assessment when designing the Subject Framework. These should only be listed for the three grades as details will be given in the lesson plan. The planning should also indicate the resources that will be needed to enable effective teaching, learning and assessment of Physical Sciences.

An example of a subject framework for Physical Sciences in Grades 10, 11, and 12 is presented in Table. 10.1:

Table 10.1 Subject framework for Physical Sciences in the FET Band

Subject Framework for Physical Sciences in the FET Band

Steps 1 – 3 LOs & ASs, conceptual progression and content for grades 10 - 12

Learning Outcomes	Assessment Standards	Conceptual progression						
		Topic	**Grade 10**		**Grade 11**		**Grade 12**	
			Content & Context	**Time**	**Content & Context**	**Time**	**Content & context**	
Learning Outcome 1 **Practical Scientific Inquiry and Problem-solving skills**	• **AS1** – Plan a scientific investigation • **AS2** - Conduct an investigation • **AS3** – Collect data systematically and provide reliable information • **AS4** – Able to control one variable • **AS5** – Seek patterns and trends in information collected • **AS6** – Linking collected information to existing scientific knowledge • **AS7** – Draw conclusion • **AS8** – apply given steps in a problem-	Mechanics	• ***Exp**. A trolley down an inclined plane & plot a position vs. time graph • **Exp**. Acceleration ***Exp; Experiment**		• ***Inv**. Relationship between normal force & maximum static friction • **Inv**. Effect of different surfaces on maximum static friction with the same object • **Inv**. Relationship between force & acceleration • **Exp**. Verify the value for **g** ***Inv. : Investigations**		• **Exp.** Conservation of linear momentum • **Exp.** Draw graph of position vs. time & velocity vs. time for a free falling object AND use the data to determine the acceleration due to gravity • **Exp.** Simple experiment to determine the work done in walking (or running) up a flight of stairs, by timing the run and walk to enrich the concept of power	
		Waves, sound & Light	• **Exp**. Ripple tank to demonstrate contractive & destructive interference of two pulses		• **Project:** verify Snell's Law & determine the refractive index of an unknown solid transparent material using Snell's Law • **Exp**. Determine the critical angle of a rectangular glass (clear)		•	
		Electricity & magnetism	• **Exp.** Pattern and direction of magnetic field around bar magnet • **Exp**. Electric circuits with resistors in series and parallel measuring potential difference & Current		• ***Demo**. Get learners to observe the magnetic field around a current carrying conductor • **Demo**. Faraday's law • **Exp.** Obtain current and voltage data for a resistor and light bulb and determine which		• Exp. Determine the internal resistance of a battery • Exp. Determine the equivalent resistance using an ammeter & voltmeter and compare with theoretical value	

	solving strategy to solve standard exercises • **AS9** - Communicate information and conclusions with clarity and precision				one obeys Ohm's Law *Demo.: Demonstrations		• Exp. Investigate short circuits and open circuits	
		Matter & materials	• Make mixtures • Paper chromatography • Determine metalloids & non-metalloids of different elements available • **Exp**. Phase change of H_2O • **Exp**. Flame tests to identify metal cations & metals • **Exp**. Investigate elements & compound • **Exp**. Electrolysis of water		• **Exp.** Intermolecular forces on evaporation, surface tension, solubility, boiling point & capillarity • **Exp.** The physical properties of water (density, Boiling Point, Melting Point, effectivity as solvent, …) • **Exp.** Boyle's Law • **Exp.** Charles' Law		• **Exp.** Alkanes and alkenes reactions with bromine water and potassium permanganate • **Exp**. Alkyne reactions with bromine water and potassium permanganate • **Exp.** Esters preparation and smell identification • **Exp.** Cross-linking polymers:- polyvinyl alcohol and sodium borate to make "slime" • **Exp.** Cross-linking polymers:- white wood glue and borax to make "silly putty"	
		Chemical systems	• **Exp**. Test H_2O for carbonates, chlorides, nitrates, nitrites, pH & look for water sample under microscope • **Project**. Purification and water quality		• **Exp.** Mass of PbO_2 prepared from $Pb(NO_3)_2$ • **Exp.** Do redox reaction that include each of the following synthesis reaction: decomposition, displacement • **Exp.** The reduction of hydrogen sulphide & the oxidizing action of potassium permanganate on various substances		•	
			• **Exp**. Prove the Law of conservation of matter • Exp. Identify chemical reaction types		• **Exp.** Investigate Endothermic reactions & exothermic reactions • **Exp.** Do experiment around natural indicators • **Exp.** Use acid base reactions to produce and isolate salts		• **Exp.** Quantitative reaction rate and graphs in the reaction between $Na_2S_2O_3$ and HCl • **Exp.** Equilibrium and the factors influencing equilibrium on $CoCl_2$ and H_2O • **Exp.** Design and perform exp. To investigate effects of pH on equilibrium systems	

		Chemical change					• **Exp.** Prepare a standard solution for volumetric analysis • **Exp.** Acid-base titration using suitable indicator • **Exp.** Use titration experiment to the concentration of acetic acid in vinegar or concentration of sodium hydroxide in drain cleaner • **Exp.** Acid-base titrations to determine presence of acid in compound • **Exp.** Electrolysis of water & sodium iodide • **Exp.** Find the Galvanic cell with the highest potential • **Exp.** Reduction of metal ions and halogens	
Learning Outcome 2 **Constructing and applying scientific knowledge**	• **AS1** - Recalling, stating basic prescribed scientific knowledge • **AS2 -** Discussing prescribed scientific theories and models by indicating some of the relationships of	Mechanics	• Vectors & scalars • Motion in One dimension • Instantaneous speed & velocity and equations of motion • Energy	4 hrs 8 hrs 8 hrs 8 hrs	• Vector in two dimensions • Newton's Laws & application of Newton's Laws	4 hrs 23 hrs	• Momentum & impulse • Vertical projectile motion • Work, energy & power	13 hrs 5 hrs 10 hrs
		Waves, sound & Light	• Transverse pulses on a string/spring • Transverse waves • Longitudinal waves • Sound • Electromagnetic radiation	4 hrs 2 hrs 4 hrs 2 hrs 4 hrs	• Geometrical optics • 2D & 3D wave fronts	10 hrs 3 hrs	• Doppler effect	6 hrs
		Electricity & magnetism	• Magnetism • Electrostatics • Electric circuits	6 hrs 4 hrs 8 hrs	• Electrostatics • Electromagnetism • Electric circuits	6 hrs 6 hrs 8 hrs	• Electric circuit • Electrodynamics	4 hrs 8 hrs
		Matter &	• Revise matter & classification • States of matter & kinetic molecular	2 hrs 2 hrs	• Ideal gases & thermal properties • Molecular structure • Intermolecular forces	8 hrs 6 hrs 10 hrs 8 hrs	• Optical phenomena & properties of materials • Organic molecules • Organic	6 hrs 12 hrs

	different facts and concepts with each other • **AS3** - Applying scientific knowledge in familiar, simple contexts • **AS4** – Categorises information • **AS5** – Find information from other sources	materials	theory • Atomic structure • Periodic table • Chemical bonding • Particles substances are made of	4 hrs 4 hrs 4 hrs 8 hrs	• Ideal gases & thermal properties		macromolecules	4 hrs
		Chemical systems	• Hydrosphere	8 hrs	• Lithosphere	8 hrs	• Chemical industry	6 hrs
		Chemical change	• Physical & chemical change • Representing chemical change • Reaction in aqueous solution • Stoichiometry (Quantitative aspects of chemical change)	4 hrs 4 hrs 8 hrs 8 hrs	• Stoichiometry • Energy & change • Types of reactions	12 4 hrs 12	• Reaction rate • Chemical equilibrium • Acids & bases • Electrochemical reactions	4 hrs 8 hrs 8 hrs 8 hrs
Learning Outcome 3 **The nature of science and its relationship to technology, society and the environment**	• **AS1** - Evaluating knowledge claims • **AS2** - Evaluating the impact of science on human development • **AS3** - Evaluating the impact of science on the environment and sustainable development	Mechanics	• Transportation • Planets and their movements • Astronomy, cosmology • Machines & mechanics • Structure, including architecture • Weather systems		• IKS: First people to make fire using friction • Transportation • Movement • Astronomy, cosmology • Road accidents • structures		• Transportation • Planets and their movements • Astronomy, cosmology • Machines & mechanics • Structure, including architecture • Weather systems	
		Waves, sound & Light	• **IKS**: Waves associated with natural disaster • Communication • Medical technology, sonar • Astronomical and terrestrial speed determination, cosmology, • Cellular communication • Solar energy	0.5 hr	• Communication • Medical technology • Astronomical instruments • Starlight and sunlight • Eyes, human and animal • earthquakes		• Communication • Medical technology, sonar • Astronomical and terrestrial speed determination, cosmology, • Cellular communication • Solar energy	
		Electricity & magnetism	• Information technologies • Social & societal changes • Digital (e-) communications • Medical technologies • Storage and transport		• Medical technologies • Communication • Storage and transport of energy • ESKOM power grid • Lightning as electric or capacitative discharge • Aurora, cyclotrons		• Information technologies • Social & societal changes • Digital (e-) communications • Medical technologies • Storage and transport	

			of energy • Lightning as electric or capacitative discharge • Cellular communication • Power generation, power grid • Solar energy				of energy • Lightning as electric or capacitative discharge • Cellular communication • Power generation, power grid • Solar energy	
		Matter & materials	• Chemistry around us • Chemistry in the home • Strengths of materials		• Chemistry in the home • Strengths of materials • Nuclear energy in South Africa • Uses of nuclear technology • Radioactivity in medicine		• Chemistry in the home • Science in fashion • Medical & industrial uses of lasers • Astrophysics • Civil engineering	
		Chemical systems	• Waste management • Water management		• Waste management • Mining and mineral processing • Alternative energy sources • Pollution, dealing with pollution and its prevention		• Waste management • Mining and mineral processing • cosmetology	
		Chemical change	• Chemistry in the home • Human nutrition		• Alternative fuel • Mining and		• Mining and mineral processing • Polymers, paints and plastic	

Step 4 Assessment of the learning and teaching process in Physical Sciences

The following types, methods, techniques, and tools of assessment should be used throughout the year to assess learning and teaching of Physical Sciences:

- Types of assessment: - baseline, diagnostic, formative, and summative
- Methods of assessment: - self-assessment, peer assessment, group assessment, and teacher assessment
- Assessment techniques: - Observation-based assessment, task-based assessment, test-based, and examination-based assessment
- Tools of assessment: - rating scales, task lists, check lists, rubrics

- Informal assessment tasks (i.e. homework tasks, class tasks, practical investigations, experiments, projects and informal tests) will be used to structure the acquisition of knowledge and skills and will be precursor to formal tasks in the Programme of Assessment (DBE, 2011:143).
- Formal assessment tasks (e.g. tests, examinations, practical tasks, projects, oral presentations, demonstrations, performances, etc) will provide teachers with a systematic way of evaluating how well learners are progressing in a grade (DBE, 2011:144).
- Both Informal and Formal assessments should serve the teacher and learner oriented CASS benefits.
- Formal assessment tasks will form part of the following year-long formal Programme of Assessment in each grade:

Figure 10.2: Programme of Assessment in the FET Band (DBE, 2011:147-148)

PROGRAMME OF ASSESSMENT FOR GRADES 10 & 11						
ASSESSMENT TASKS 25%						**END-OF-YEAR ASSESSMENT 75%**
TERM 1		**TERM 2**		**TERM 3**		**TERM 4**
Type	%	Type	%	Type	%	
Experiment	20	Experiment	20	Project: **ANY ONE OF**: Poster/construction of device/building a model/Practical investigation	20	**Final Examination** (2 x 150 marks, giving a total of 300 marks for papers 1 and 2)
Control tests	10	Mid-Year examination	20	Control test	10	
Total: 30 marks		**Total: 40 marks**		**Total: 30 marks**		**Total: 300 marks**
Total = 400 marks						

PROGRAMME OF ASSESSMENT FOR GRADE 12						
ASSESSMENT TASKS 25%						**END-OF-YEAR ASSESSMENT 75%**
TERM 1		**TERM 2**		**TERM 3**		**TERM 4**
Type	%	Type	%	Type	%	
Experiment	15	Experiment	15	Experiment	15	**Final examination** (2 x 150 marks, giving a total of 300 marks for papers 1 and 2)
Control test	10	Mid-year examination	20	Trial examination	25	
Total: 25 marks		**Total: 35 marks**		**Total: 40 marks**		**Total: 300**
Total = 400 marks						

Step 5 Using essential resources

The following resources are essential for effective teaching, learning and assessment of Physical Sciences in the FET band:

- A fully equipped functional laboratory with relevant prescribed chemicals for Physical Sciences in the FET band schools
- Laboratory rules for each learner and one pasted on a visible place in the laboratory
- Small Scale apparatus
- Classroom & Laboratory Periodic Tables
- An approved relevant text book for each learner
- Mathematical instrument for each learner
- Scientific calculator for each learner
- Fire extinguishers
- Over head projector
- Media resources (at least a TV & DVD player and computer with internet access)
- Science library books
- Running water and electricity

After the Subject Framework has been designed, attention can be given to designing a work schedule for each grade.

10.3.2 Designing the Work Schedule

A work schedule should be designed for each grade. The design of a work schedule should be informed by the subject framework and should reflect what teaching and assessment will take place in the 36 to 40 weeks of the school year.

According to the Curriculum and Policy Statement (CAPS) (DBE, 2011:9), the teaching time for Physical Sciences in FET band schools is four hours per week with 40 weeks in total per grade. This time allocation includes the teaching of content, concepts and skills, including the practical work. Figure 10.4 below shows the time allocation for Physical Sciences in the FET band.

Figure 10.3 Time allocation for Physical Sciences in the FET Band

Grade	Teaching and Learning time (weeks)	Formal assessment (weeks)	Total number of weeks allocated
10	30	10	40
11	30	10	40
12	29	11	40

(Derived from DBE, 2011)

Based on the time allocation for Physical Sciences in the FET band above, an overview of the topics for Physical Sciences across the three grades per content is given in Figure 10.4 below.

Figure 10.4 Overview of Physical Sciences topics (DBE, 2011:10-11)

Topic	Gr.	Content	Time (hours)	
			Per content	Sum
Mechanics	10	Vectors and scalars	4	28
		Introduction to vectors & scalars: Motion in one dimension	8	
		Instantaneous speed and velocity and the equations of motion	8	
		Energy	8	
	11	Vectors in two dimensions	4	27
		Newton's Laws and application of Newton's Laws	23	
	12	Momentum and Impulse	13*	28
		Vertical projectile motion	5*	
		Work, Energy and power	10	
Waves, Sound & Light	10	Transverse pulses on a string or spring	4	16
		Transverse waves	2	
		Longitudinal waves	4	
		Sound	2	
		Electromagnetic radiation	4	
	11	Geometrical Optics	10	13
		2D & 3D Wave fronts	3	
	12	Doppler effect (either moving source or moving observer)	6	6
Electricity & Magnetism	10	Magnetism	2	14
		Electrostatics	4	
		Electric circuits	8	
	11	Electrostatics	6	20
		Electromagnetism	6	
		Electric circuits	8	
	12	Electric circuits	4	12

		Electrodynamics	8	
Matter & Materials	10	Revise matter and classification	2	24
		States of matter and the kinetic molecular theory	2	
		Atomic structure	4	
		Periodic table	4	
		Chemical bonding	4	
		Particles substances are made of	8	
	11	Ideal gases and thermal properties	8	
		Molecular structure	6	32
		Intermolecular forces	10	
		Ideal gases and thermal properties	8	
	12	Optical phenomena and properties of materials	6	22
		Organic chemistry	12*	
		Organic macromolecules	4	
Chemical Systems	10	Hydrosphere	8	8
	11	Lithosphere	8	8
	12	Chemical industry	6	6
Chemical Change	10	Physical and chemical change	4	24
		Representing chemical change	4	
		Reactions in aqueous solution	8	
		Stoichiometry (quantitative aspects of chemical change)	8	
	11	Stoichiometry (quantitative aspects of chemical change)	12	28
		Energy and chemical change	4	
		Types of reactions	12	
	12	Reaction rate	4	28
		Chemical equilibrium	8	
		Acids and bases	8	
		Electrochemical reactions	8	

In designing the Work Schedule, consideration should be given to the following aspects:

- The time and duration of the study of each part of the content as depicted in Figure 10.4 above
- The LOs and ASs that have to be achieved in a holistic manner for a particular grade
- The order in which the groupings of LOs and ASs will be presented
- Content and concepts that promote learning to the attainment of ASs as smaller units of the LOs
- Practical work, projects, demonstrations and experimentation that lead to the attainment of ASs and LOs
- Assessment types, methods, techniques and tools
- Integration with other subjects
- Resources that will be needed

Based on the above, an example of the work schedule for Grade 10 Physical Sciences for the year 2012 is presented in Table 10.2:

Table 10.2 **Example of work schedule for Grade 10 Physical Sciences (YEAR: 2012)**

Duration	Learning Outcomes In check list	Content	Context	Assessment	Resources	Integration
WEEK 1 Term 1 18-20/01/2012	Practical scientific inquiry and problem solving skills. Constructing and applying scientific knowledge. The nature of science and its relationship to technology, society and the environment.	Orientation and Laboratory Safety Rules	Administration	Appropriate types, methods, tools and techniques should be employed. Only *RPA for Informal Assessment tasks and *PPA are given.	Laboratory Chart	Life Orientation, Arts and Culture
WEEK 2 Term 1 23-27/01/2012		-Revision: Matter & Classification -States of matter & *KMT *KMT: Kinetic Molecular Theory	Teachers are encouraged to make use of any relevant context from those that are listed in the Subject Framework or as informed by the location of the school. NB: the context should enhance effective teaching and learning.	***RPA:** Recommended Practical Activities ***PPA**: Prescribed Practical Activities		Integrate with other subjects where contact points exist. (e.g. Mathematics, Life Orientation, Arts and Culture, Economics, etc.) Integrate within the Subject to ensure that all ASs for a particular grade are covered in the particular contact period.
WEEK 3 Term 1 30/01-3/02/		Atomic structure		**RPA**: Flame tests to identify some metal cations and metals.	Watch glass, burner, propette, methanol, bamboo stick, metal salts to be tested including NaCl, $CuCl_2$, $CaCl_2$, KCl and powder of metals Cu, Mg, Zn, Fe, etc.	
WEEK 4 Term 1 06-10/02		Periodic Table				
WEEK 5 Term 1 13-17/02		Chemical Bonding				
WEEK 6 Term 1 20-24/02		Transverse pulses on a string/spring		**RPA**: Demonstrate constructive & destructive interference of 2 pulses	Ripple tank apparatus.	
WEEK 7		Transverse & Longitudinal				

Term 1 27/02-02/03		waves				
WEEK 8 Term 1 05-09/03		Longitudinal waves & Sound				
WEEK 9 Term 1 12-16/03		Electromagnetic radiation				
WEEK 10 Term 1 19-23/03		Revision	Prescribed Practical Assessment Activity	**PPA**: Heating and cooling curve of H_2O	Burner, ice water, glass beaker & a thermometer.	
WEEK 11 Term 1 26-30/03	**1st Term Formal Assessment Tests**					
WEEK 12 Term 2 10-13/04		Feedback on Test			Question paper and answer scripts	
WEEK 13-14 Term 2 16-26/04		Particles substances are made of		**RPA:** Prove the conservation of matter experimentally.	Test tubes, glass beaker, lead(II)nitrate, NaI, NaOH HCl, bromothymol blue, 1 Cal-C-Vita tablet, plastic bag, rubber band & mass meter.	
WEEK 15 Term 2 02-04/05		Magnetism		**RPA:** Pattern and direction of the magnetic field around bar magnet.	Bar magnet, iron fillings & a sheet of A4 paper, several small compasses.	
WEEK 16 Term 2 07-11/05		Electrostatics				
WEEK 17-18 Term 2 14-25/05		Electric circuits				
WEEK 19 Term 2 28/05-01/06		Physical and chemical change				

WEEK 20 Term 2 04-08/06		Representing chemical change				
WEEK 21 Term 2 11-15/06		Revision	Prescribed Practical Assessment Activity.	**PPA**: Electric circuit with resistors in series and parallel measuring the potential difference	Light bulbs, resistors, batteries, switches, connecting leads, ammeters, voltmeters.	
WEEK 22 Term 2 18-22/06	**Mid-Year Examination**					
WEEK 23 Term 3 16-20/07		Feedback on Mid-Year Examination			Question paper and answer scripts.	
WEEK 24-25 Term 3 23/06-03/08		Reactions in aqueous solution				
WEEK 26-27 Term 3 06-17/08		Stoichiometry		**RPA:** Reaction types:precipitation, gas forming, acid-base & redox.	Soluble salt to form precipitations, acids and bases, $NaCO_3$ & HCl, $Pb(NO_3)_2$ & NaBr, $Na_{(s)}$ & Manganese dioxide, Copper(II)sulphate & thin copper wire, burner.	
WEEK 28 Term 3 20-24/08		Vectors and scalars				
WEEK 29-30 Term 3 27/08-07/09		Motion in one dimension		**RPA:** A trolley down an incline plane with ticker tape attached used to plot a position vs. time graph.	Trolley, ticker-timer, ticker tape apparatus, tape, graph paper, stop watch	
WEEK 31 -		Instantaneous speed and				

32 Term 3 10-21/09		velocity and the equations of motion				
WEEK 33 Term 3 25-28/09		**3rd term Formal assessment**		**PPA:** Measuring the acceleration of an object **OR Project**: Purification and quality of water	Trolley, ticker-timer, ticker tape apparatus, tape, graph paper, stop watch.	
WEEK 34 Term 4 08-12/10		Feedback on Control Test			Question paper and answer scripts	
WEEK 35-36 Term 4 15-26/10		Energy				
WEEK 37-38 Term 4 29/10-09/11		Hydrosphere		RPA: Test H_2O samples for carbonates, chlorides, nitrates, nitrites, pH & look at H_2O sample under the microscope.	TETRA-test (Pet shop), silver nitrate, microscope or magnifying glass, filter paper and funnel.	
WEEK 38 Term 4 12-16/11	Revision and finalising portfolios					
WEEK39–41 Term 4 26-30/11	**Final Examination**					
WEEK 42 Term 4 3-7/12	Planning for 2013					

Once the Work Schedule has been designed, the teachers who are responsible for teaching Physical Sciences in the FET band schools should each map out the Lesson Plan for each grade from the Work Schedule.

10.3.3 The Lesson Plan

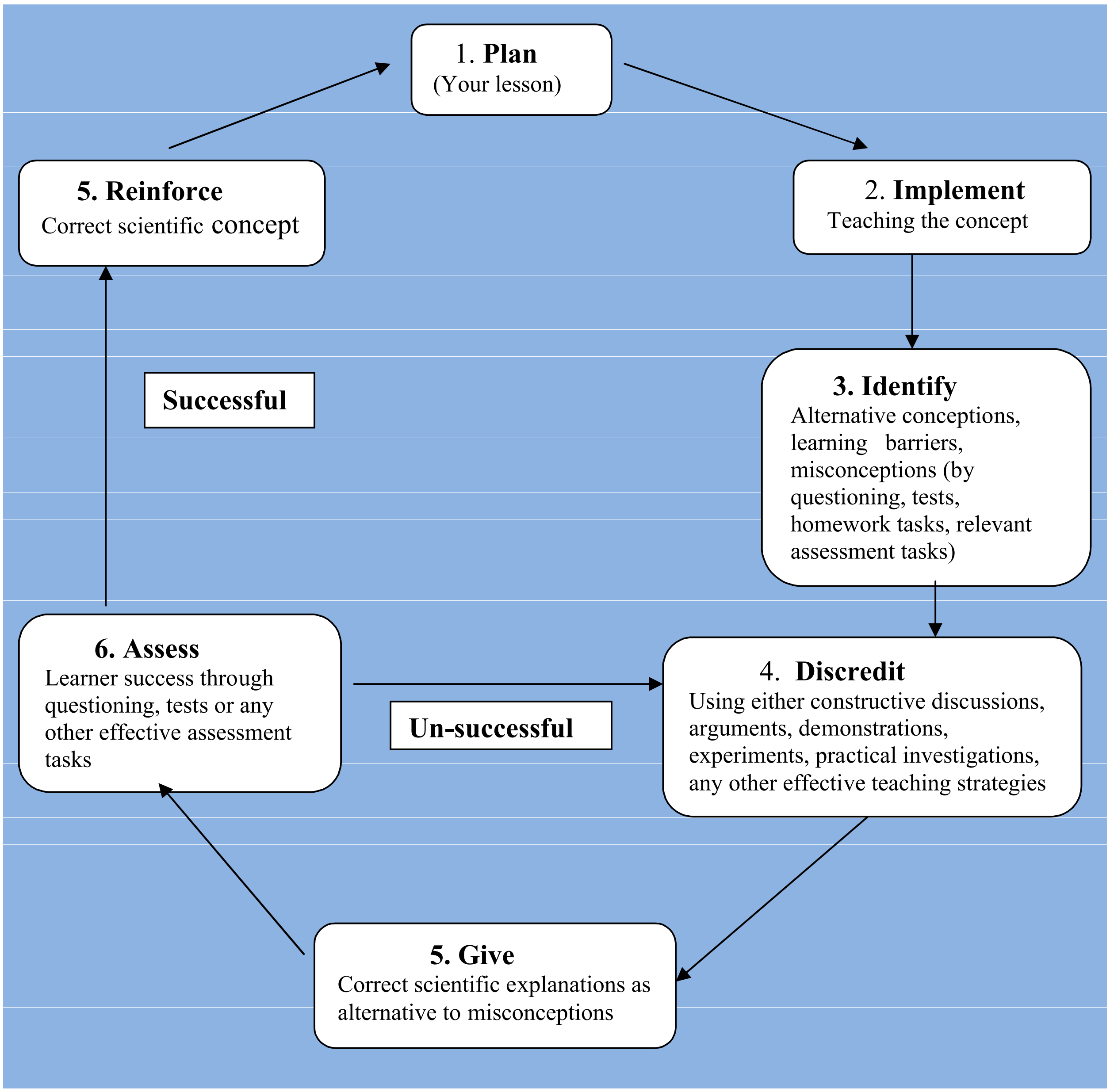


Figure 10.5 A basic lesson plan for teaching Physical Sciences in the FET Band

Teaching (Figure 10.1) starts with a basic lesson plan. The lesson plan should contain a coherent series of teaching, learning and assessment activities. The next step is the implementation of the plan, where the teacher introduces the concept to be learned and also makes assessment standards known to the learners. This step leads to the identification of alternative conceptions or misconceptions and learning barriers. If alternative conceptions or barrier/s of learning is identified, different teaching strategies must be employed to uproot the alternative conception. This can take the form of demonstrations, experiments, any practical investigation or any other effective teaching strategy. The next step is giving the correct scientific explanations as an alternative to the misconception(s). This is followed by the assessments to check if the alternative conception(s) is still in existence. If the misconception is successfully uprooted, the correct scientific concept is reinforced. But, if the assessments do not yield positive results, then the teacher returns to step 4 of the plan, were he/she has to discredit the misconception(s) using other teaching strategies that may yield positive results. The next steps are followed until the learners demonstrate competence. Once ASs or LOs have been successfully attained, teaching and learning may progress to the next level.

Assessment does not take place in isolation. Thus, the OBA model will not make sense if it is dealt with in isolation. It is part of a structured approach to teaching and learning of Physical Sciences, and this structured approach starts with designing a Learning Programme, as indicated in paragraph 10.3.

Despite the fact that the Work Schedule depicts what should be taught, a Lesson Plan has to be designed for each grade. The Lesson Plan adds to the level of detail in the Work Schedule and it is here that the Model for Assessment fits in. It also indicates other relevant issues to be considered when teaching and assessing Physical Sciences. For that reason, thorough planning should be done for each lesson that is part of a learning cycle based on a particular content. It might be easier to follow the following steps (Reyneke, 2008:176 – 177):

1. Calculate the number of lessons available in the learning cycle (keep school organisation, public holidays, etc. in mind).
2. Decide on an interesting way to introduce the content to the learners.
3. Check the availability of the resources.
4. Plan concept linking activities that will lead to the attainment of knowledge and skills in each of the LOs and allocate a number of lessons to each.
5. Tick off (in checklist or frequency table – see Appendix I) the ASs that will be used as learning outcomes in each lesson. (These outcomes will be shared with the learners at the beginning of the learning cycle).
6. Use ASs to pin down learning activities assessable tasks.
7. Select the most appropriate assessment types, methods, techniques and tools of assessment for each task, making sure that a variety of each is used.

8. Design assessment tools where needed. Incorporate ASs as criteria in rubrics, checklists, task lists and observation sheets.
9. Decide on the most appropriate teaching strategies for each lesson.
10. Decide which assessment results will be recorded for CASS mark.

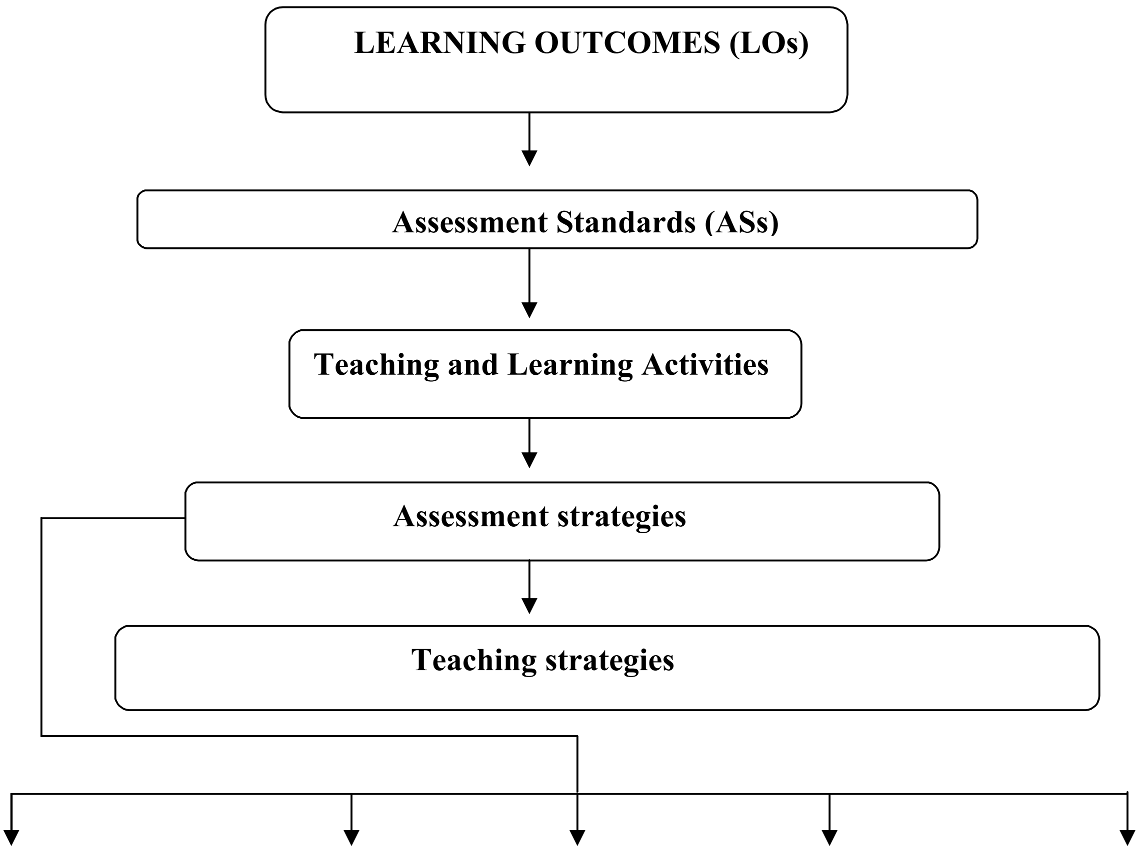
Due to the nature of the subject of Physical Science, it is important for teachers to plan their assessment tool before entering an inquiry-oriented class. This enables the teacher to interact appropriately with the learners. Even though a series of questions are planned, teachers must be willing to deviate from them and formulate new ones as they interact with learners.

When designing the assessment tool, teachers must incorporate the ASs in the form of criteria. This will ensure that the desired outcomes are achieved. In this way (Reyneke, 2008:176), the teacher makes assessment an integral part of teaching and learning and acknowledges it as the driving force behind both. The teacher can use various strategies to provide an environment that is conducive for learners to construct knowledge of concepts, skills, values and attitudes necessary for achievement. Learners must be able to apply the acquired knowledge, skills, values or attitude by performing an activity so that the teacher can assess whether they have learnt and can establish what they have learnt. This process is called assessment (Latin: *assidere,* meaning sitting beside) because it plays a formative and diagnostic role and provides both the teachers and the learners with the information they need.

It is important for learners to know what knowledge and skills are going to be assessed and feedback should be provided to learners after assessment to enhance the learning experience (DBE, 2011:4).

According to the Learning Programme Guidelines, the lesson planning process should be designed down from the LOs as indicated below (DoE, 2005b:19 and Reyneke, 2008:177):

Figure: 10.6 Lesson design down process



Form of Assessment	Types of Assessment	Method of Assessment	Assessment Technique	Assessment Tool
Informal = daily and continuous, may use an assessment tool. Formal = always make use of an assessment tool	Baseline Diagnostic Formative Summative	Self Peer Group Teacher Parent	Observation-based Test-based Task-based Exam-based Practical investigation Experimentation	Rubrics Checklist Task list Observation schedule, Memoranda Rating scale

Since the Lesson Plan is not equivalent to a subject period in the school timetable, the following template is designed to practically illustrate how teaching, learning and assessment should be integrated when planning assessment for each learning cycle or topic. Since assessment cannot be dealt with in isolation, a cycle plan for twenty-three 40-45 minutes lessons has been designed to practically illustrate how teaching, learning, and assessment should be integrated. Table 10.4 serves as a model for Outcomes-Based Assessment of Grade 10 Physical Sciences in the FET Band.

10.4 A model for effective OBA of Grade 10 Physical Sciences in the FET Band

Table 10.3: A model for assessment of Grade 10 Physical Sciences in the FET Band

Lesson	Learning Outcomes(LOs) and ○ Assessment standards (ASs)	Detail of Activity		Assessment strategies					
		Planned learner activities	**Teacher activities**	**Assessment tasks/evidence of performance**	**Formal / Informal assessment**	**Types of assessment:** • Baseline • Diagnostic • Formative • Summative	**Method of assessment (Who assesses?)** • Self • Peer • Group • Teacher • Parent	**Assessment technique:** • Observation • Task-based • Test-based • Exam-based	**Assessment tool:** • Rubric • Memo • Checklist • Rating scale • Observation sheet • Task list
1	• **Learning Outcome 1** ○ Conduct in the classroom ○ Collect data systematically, accurately and provide reliable information ○ Seek pattern and trends in information collected ○ Linking collected information to existing knowledge ○ Draw conclusion ○ Communicate information and conclusions with clarity and	• Propose class rules • Object to some rules • Propose steps to be taken on offenders • Vote for rules • Sign the class rules • Complete the personal information form (see Appendix L).	• Orally introduce the class rules • Orally explains the importance of class rules • Ask learners to propose class rules • Learners vote for the proposed rule • Give reason for objecting to the rule • Explain steps to be taken when a learner does not adhere to the rules • Write the rules on the chalkboard and make a copy of it for each learner to have and sign • Explain the	Give class rules	Informal	Baseline	Teacher	Task-based	
				Explain the importance of class rules	Formal	Formative	Teacher	Task-based	
				Vote for the rules	Formal	Formative	Teacher	Observation-based	
				Give reason for objecting to the rule	Informal	Formative	Teacher	Task-based	
				Decide on steps to be taken when rules are not obeyed	Informal	Formative	Teacher	Task-based	
				Sign the class rules	Formal	Summative	Teacher	Observation-based	
				Explain the importance of completing personal Information form	Informal	Formative	Teacher	Task-based	

	precision		importance of completing the personal information form • Observe the completion of the form and provide assistance were necessary	Complete the personal information form	Formal	Formative	Teacher	Observation-based	
2	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	• Locate the laboratory • Tour the laboratory • Discuss the use of the laboratory • Identify the chemicals and how they are arranged • Explain why chemicals are arranged in the order they are arranged	• Explain what the laboratory is and what takes place in the laboratory • Tour the laboratory • Show the learners the emergency exit • Explain when to use the emergency exit • Show learners the eyewash station • Explain when to use the eyewash station • Show learners the safety shower and explain when to use it • Show learners the safety equipments, its location and how to use each of them • Show learners where chemicals are stored	• Orally explain what the laboratory is	Informal Formal	Baseline Formative	Teacher Peer	Task-based	
				• Explain the lay-out of the laboratory	Formal	Formative	Teacher	Task-based	
				• State the importance of laboratory	Formal	Formative	Teacher Peer	**Task-based**	
				• Identify the chemicals and how they are arranged	Formal	Formative	Teacher	Observation-based	
				• Explain the arrangement of the apparatus in the laboratory	Formal	Formative	Teacher	Observation-based	
				• Explain why chemicals are arranged the way they are arranged	Formal	Formative	Teacher	Task-based	
				• Identify the emergency exit	Formal	Formative	Teacher	Observation-based	
				• Explain when to use the emergency exit	Formal	Formative	Peer Teacher	Task-based	

				• Identify the location of safety equipment	Formal	Formative	Teacher	Observation Task-based	
				• Explain how to use the safety equipment (e.g. fire extinguisher, fire blanket, etc.)	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
3	• **Learning Outcome 1** ○ Conduct scientific investigation ○ Collect data systematically, accurately and provide reliable information ○ Seek pattern and trends in information collected ○ Linking collected information to existing scientific knowledge ○ Draw conclusion ○ Communicate information and conclusions with clarity and precision • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with	• Laboratory rules (Appendix J) • Laboratory safety signs (Appendix K) • Name the safety signs on the bottle of hydrochloric acid • Observe the demonstration • Write down what they observe • Discuss the lab rules • Work in groups, inferring the meaning of lab safety signs • Paste the safety symbols chart on the wall of the laboratory where everyone who enter the lab can see it	• Wear the laboratory outfit • Explain the importance of wearing the laboratory outfit • Explain the laboratory rules (Appendix J) • Explain the reason for each of the laboratory rules • Explain the importance of abiding by the lab rules • Show the laboratory symbols learners may encounter in the laboratory • Explain the meaning of each symbol • Demonstrate the danger we might encounter if we do not behave properly • Demonstrate what the acid can do when it enters the eye of an individual using the acid and the egg	• Discuss the laboratory rules	Informal formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain what the laboratory safety outfit is	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain the importance of wearing laboratory outfit	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Propose the lab rules and give reason for the lab rules	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Name the safety signs on the bottle of an acid	Formal	Formative	Teacher	Observation Task-based	
				• Explain the meaning of the safety symbol/sign	Formal	Formative	Teacher	Task-based	
				• Observe the disadvantage of not following the lab instructions	Formal	Formative	Teacher	Observation	
				• Discuss what they observed	Informal	Diagnostic Formative	Peer Teacher	Task-based	
				• Name the safety symbol on some of the chemicals	Formal	Formative	Teacher	Task-based	

	each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources • **Learning outcome 3** ○ Describe the interrelationship and impact of science and technology on socio-economic and human development ○ Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on the immediate environment ○ Suggest ways in which to improve technological products			• Give the meaning of the safety symbol	Formal	Formative	Teacher	Task-based	
4	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts	• Complete the first part of the form to set learning goals for the cycle (Appendix M) • Orally give examples of matter • Define matter • Give examples of matter around us • Classify given examples • Orally define the concepts mixture, homogeneous, and heterogeneous • Discuss further	• Share learning objectives with learners (see Appendix M) • Give each learner a form to complete to set learning goals • Introduce the topic 'matter' • Explains what matter is • Write down examples of matter given by learners • Give the properties of matter • Define mixture,	• Orally introduce the concept matter by giving examples	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Orally define matter	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Classify the written/given examples according to their properties	Formal	Formative	Teacher	Task-based	
				• Describe the properties of matter	Formal	Formative	Teacher	Task-based	

	○ Categorises information	examples of homogeneous and heterogeneous mixtures • Classify substances as homogeneous and heterogeneous mixture **(Exercise 1)**(see Appendix W) • Give answers to exercise 1 • Mark own work • Do corrections	homogenous and heterogeneous mixtures • Classify substances as homogeneous and heterogeneous mixtures • Give learners an exercise **(Exercise 1)** (see Appendix W) • Give correct answers to the exercise (Exercise 1)	• Identify a mixture • Define mixture, homogeneous and heterogeneous	Formal	Diagnostic Formative	Teacher	Observation	
				• Identify homogeneous and heterogeneous mixtures	Informal Formal	Diagnostic Formative	Peer Teacher	Observation	
				• Explain the properties of homogeneous and heterogeneous mixtures they identified	Formal	Formative	Teacher	Task-based	
				• (**Exercise 1)** classify the given substances as homogeneous and heterogeneous mixtures (Appendix W)	Informal Formal	Formative	Self Teacher	Observation-based	Memorandum (Appendix W)
5	• **Learning Outcome 1** ○ Conduct scientific investigation ○ Collect data systematically, accurately and provide reliable information ○ Seek pattern and trends in information collected ○ Linking collected information to existing scientific knowledge ○ Draw conclusion ○ Communicate information and conclusions with clarity and	• Orally give definitions of elements and compounds • Write correct scientific definitions for elements and compounds • Orally distinguish between elements and compound • Collect worksheet 1(Appendix O) and apparatus • Study the worksheet • Observe phenomena, describe concepts, classify and use materials	• Explain elements and compounds • Write the definitions on the chalkboard • Gives distinct between elements and compounds • Check apparatus • Give instructions • Observe and assist • Give feedback • Explain how to go about doing the homework • Explain how the checklist will be used to mark the homework • Ensure that every learner understands what is expected of	• Give definition of element and compound	Formal	Formative	Teacher	Task-based	
				• Distinguish between elements and compounds and give examples of each	Formal	Formative	Teacher	Task-based	
				• Give examples of elements and compounds they know	Formal	Formative	Teacher	Task-based	
				• **Experiment 1: Paper Chromatography** (Appendix O)	Formal Formal	Formative Diagnostic	Peer Teacher	Task-based Observation	Memorandum Rating scale (see Appendix O)

	precision • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources • **Learning outcome 3** ○ Discuss knowledge claims by indicating the link between indigenous knowledge system and scientific knowledge ○ Describe the interrelationship and impact of science and technology on socio-economic and human development ○ Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on immediate environment ○ Suggest ways in	• Conduct experiment • Observe • Record results of experiment • Peer assess the experiment • Rate each other • Collect the checklist for marking of the homework • Study the checklist (see Appendix N) • Do Homework	him/her • Give every learner a checklist for the table to be marked	• Indicate what colour mixture each of the water soluble ink pens contain or • Indicate what colour mixture "smarties" contain.					
				• Orally give the separation techniques for the given mixtures	Informal	Diagnostic Formative	Self Parent Peer	Practical	
				• **HOMEWORK ACTIVITY 1** (Appendix X) Identify 6 mixtures at home	Informal	Baseline	Self Parent Peer	Task-based	Checklist

	which to improve technological products								
9	• **Learning outcome 1** ○ Plan a scientific investigation ○ Conduct a scientific investigation ○ Collect data systematically, accurately and provide reliable information ○ Link collected information to existing scientific knowledge ○ Draw conclusion ○ Communicate information and conclusions with clarity and precision • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorises information ○ Finds information from other	• Mark partner's homework using the checklist and rating scale (Appendix N) • Defend their position • Do corrections • Name separation techniques for the given mixtures • Listen to instructions • Propose different actions to differentiating amongst materials • Perform experiment • Observe and record results • Explain the use of properties of metals at home • Orally answer questions based on metals, non-metals and insulators • Orally respond to questions based on thermal conductors • Test and classify material as thermal conductors and insulators • Record their results • Test and classify materials as magnetic and non-magnetic • Mark their practical work and do corrections	• Facilitate the marking of the homework activity 1 • Group learners and assigns worksheet (Appendix N) and apparatus • Give instructions • Listen and observe as practical work unfolds • Provide help where necessary • Explain the properties of metals, metalloids and non-metals • Give the results of the experiments • Explain the results of the experiment • Facilitate the marking of the experiment results	• Mark partner's homework	Informal	Formative	Peer	Observation-based	Checklist and rating scale (Appendix N)
				• Classify substances as metals, metalloids and non-metals	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Identify the position of metals, metalloids and non-metals in the periodic table	Informal Formal	Diagnostic Baseline Formative	Peer Teacher	Task-based	
				• Describe metalloids	Formal	Formative	Teacher	Task-based	
				• Orally explain what thermal conductors are	Informal Formal	Baseline	Peer	Task-based	
				• Orally give examples of materials that are thermal conductors	Informal	Baseline	Peer	Task-based	
				• Orally give examples of materials that are insulators	Informal	Baseline	Peer	Task-based	
				• Orally give actions to differentiate between electrical conductors and insulators	Formal	Formative	Teacher	Task-based	
				• Orally give actions to differentiate between thermal	Formal	Formative	Teacher	Task-based	

	sources • **Learning outcome 3** ○ Discuss knowledge claims by indicating the link between indigenous knowledge system and scientific knowledge ○ Describe the interrelationship and impact of science and technology on socio-economic and human development ○ Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on immediate environment Suggest ways in which to improve technological products			conductors and insulators					
				• Orally give actions to differentiate between magnetic and non-magnetic materials	Formal	Formative	Teacher	Task-based	
				• **Experiment 2**: (Appendix R) Properties of Metals **Activity A**: Test substances and classify them as conductors, semiconductors and insulators	Formal	Formative	Peer	Practical	Memorandum and rating scale
				• **Activity B**: Test and classify substances as thermal conductors and insulators	Formal	Formative	teacher	Practical	Memorandum and rating scale
				• **Activity C**: Test and classify materials as magnetic and non-magnetic	Formal	Formative	Teacher	Practical	Memorandum and rating scale
				• **Homework Activity 2** (Appendix X) How are the properties of metals used at home **(Kelder, 2008a:136)**	Informal	Formative	Parent Learner	Task-based	
7	• **Learning Outcome 1** ○ Collect data systematically, accurately and provide reliable	• Verbally give materials that are magnetic and those that are non-magnetic	• Explain and write the scientific definitions of magnetic and non-magnetic materials	• Give examples of materials that are magnetic and non-magnetic	Formal	Baseline Formative	Teacher	Task-based	

	information ○ Link collected information to existing scientific knowledge ○ Communicate information and conclusions accurately • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorises information	• Classify materials as magnetic and non-magnetic • Discuss and give the uses we make of magnets in our daily life • Observe and record the behaviour of potassium permanganate in water • Orally give the states in which matter may exist • Orally explain what they understand by freezing, melting, and boiling point of water • Copy correct definitions in their notebooks	• Explain how to investigate the magnetic properties of solid materials • Explain the uses we make of magnetic materials in our daily life • Explain the concept diffusion • Demonstrate diffusion using potassium permanganate in water • Explain the states in which matter may exist • Explain what freezing, melting and boiling points of water are	• Give the example of the use we make of magnets in daily life	Formal	Formative	Teacher	Task-based	
				• Orally state what matter is	Informal Formal	Formative	Peer Teacher	Task-based	
				• Orally give the states of matter	Informal Formal	Formative	Peer Teacher	Task-based	
				• **Demonstration 1** Observe diffusion of KMO_4 in water	Informal Formal	Formative	Peer Teacher	Observation	
				• Define the concept diffusion	Formal	Formative	Teacher	Task-based	
				• List and characterize the three states of matter	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Define freezing point of water	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Define melting point of water	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Define boiling point of water	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
8	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing	• Write answers on their test books • Defend their responses • Rate each other • Do corrections	• Supervise marking of the test • Discuss the learners' responses • Give correct scientific answers	• **Class Test 1**	Formal	Diagnostic Formative	Teacher	Task-based	Memorandum Rating scale

	prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorises information ○ Finds information from other sources								
6	• **Learning Outcome 1** ○ Conduct scientific investigation ○ Collect data systematically, accurately and provide reliable information ○ Able to control one variable ○ Seek patterns and trends in information collected ○ Link collected information to existing scientific knowledge ○ Draw conclusion ○ Communicate information and conclusions accurately • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss	• Explain what sublimation is • Study and discuss melting points and boiling points of substances • Perform solubility of water experiment (Appendix S) • Tabulate the results of the experiment • Draw the temperature v/s time graph for solubility of water • Do corrections were necessary	• Explain what sublimation is • Demonstrates sublimation using iodine • Explain how to use the specific temperature of substances to give its state • Observe and listen to learners' discussion of the concepts freezing point, melting and boiling point of water • Group learners and give each worksheet (Appendix S) and necessary apparatus for melting of water experiment • Walk around, observe and listen to learners discussion (see Appendix T) • Assists where necessary • Mark the learners' work and assist with corrections	• Define melting and give example	Formal	Formative	Teacher	Task-based	
				• Define evaporation and give example	Formal	Formative	Teacher	Task-based	
				• Define freezing and give example	Formal	Formative	Teacher	Task-based	
				• Define sublimation and give example	Informal Formal	Baseline Formative	Teacher	Task-based	
				• **Demonstration 2** Observe the sublimation of I_2 crystal	Formal	Formative	Teacher	Demonstration	
				• Define condensation and give examples	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Identify the physical state of a substance at a specific temperature, given the melting, boiling and freezing point of a substance	Formal	Formative	Teacher	Task-based	

	prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorises information			• **Experiment 3** (Appendix S) Observe the phase change of water	Formal	Formative	Teacher	Practical	
				• Draw the graph of the phase change of water	Formal	Formative	Teacher	Task-based	Memorandum
10	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	• Explain what density, kinetic energy, melting and boiling, viscosity and thermal expansion are • Note states of matter according to KMT • Note the estimated mass and diameter of an atom • Research the life of a scientist and his/her contribution to the development of an atom	• Explain the concepts kinetic energy, melting and boiling, viscosity, and thermal expansion • Explain by giving examples the states of matter according to the KMT • Gives a rough estimate of the mass of an atom • Gives a rough estimate of the diameter of an atom • Gives the research project and explains how to design the poster • Explain how the rubric will be used to mark the poster (Appendix U) • Allocates each learner a scientist to research	• Explain the concepts kinetic energy, melting and boiling, viscosity, and thermal expansion	Informal	Baseline	Teacher Peer		
				• Describe a solid according to the KMT in terms of particles matter	Formal	Formative	Teacher	Task-based	
				• Describe a liquid according to the KMT in terms of particles matter	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Describe a gas according to the KMT in terms of particles matter	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Describe the states of matter according to the KMT	Formal	Formative	Teacher	Task-base	
				• Describe the simplest form matter can exist	Formal	Formative	Teacher	Task-based	

				• Orally describe what the atom is	Informal	Baseline	Teacher	Task-based	
				• Identify the major contributions to the current atomic model	Formal	Formative	Teacher	Task-based	
				• What is the purpose of a model of the atomic structure?	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Give a rough estimate of the mass of an atom	Formal	Formative	Teacher	Task-based	
				• Give a rough estimate of the diameter of an atom	Formal	Formative	Teacher	Task-based	
				• Orally state the contribution by Dalton on the atomic model	Formal	Formative	Teacher	Task-based	
				• **Research Activity 1: (see Appendix Y)** research the life of a scientist and his/her contribution to the atomic theory	Informal	Formative	Peer Parent	Task-based	Rubric and rating scale (Appendix R)
11	• **Learning Outcome 1** ○ Collect data systematically, accurately and provide reliable information ○ Linking collected information to existing scientific	• Orally explain what relative atomic mass and mass number are • Write correct definitions of the concepts on the note books • Observe the	• Explain the correct scientific explanation of the concept relative atomic mass and mass number and write the definitions on the chalkboard for learners to note • **Demonstration 3**	• Describe and use the concept relative atomic mass	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Explain what the Periodic Table is	Informal Formal	Baseline Formative	Teacher	Task-based	

	knowledge ○ Communicate information and conclusions accurately • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	arrangement of atoms in solids, liquids and gases and note what they observed • Listen and note how particles electrons, protons and neutrons are arranged in neutral atoms • Give the charges of protons, electrons and neutrons • Give the number of protons, neutrons and electrons in the given neutral atoms • Determine the charge of an atom when the electron is removed from the atom • Explain the term isotope • Calculate the mass number for an isotope of an element	Use Styrofoam spheres to demonstrate how atoms are arranged in gases, liquids and solid substances • Explain how particles electrons, protons and neutrons are arranged in the atom and the number of each in a neutral atom • Explain how the loss and gain of an electron affects the charge of an atom • Show how to calculate the mass number of an isotope of an element	• Describe what the element is	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Give the relationship between element and atom	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Describe how atoms are arranged in solids, liquids and gases	Formal	Formative	Teacher	Demonstration	
				• Define the concept atomic number of an element	Formal	Formative	Teacher	Task-based	
				• Give the number of the protons present in the atom of an element	Formal	Formative	Teacher	Task-based	
				• Give the number of electrons present in a neutral atom of the element	Informal Formal	Baseline Formative	Teacher	Task-based	
				• Show that by removing electrons from an atom the neutrality of the atom is changed	Formal	Formative	Teacher	Task-based	
				• Determine the charge of an atom after removing electrons from the atom	Formal	Diagnostic Formative	Teacher	Task-based	
				• Calculate the number of neutrons present in an a neutral atom	Formal	Diagnostic Formative	Teacher	Task-based	

				• Calculate the mass number for an isotope of an element	Formal	Formative	Teacher	Task-based	
				• Explain the term isotope	Formal	Formative	Teacher	Task-based	
				• Perform calculations related to isotopic masses	Formal	Diagnostic Formative	Teacher	Task-based	
				• Perform calculations related to relative atomic masses	Formal	Diagnostic Formative	Teacher	Task-based	
12	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	• Write down the meaning of the superscript A and sub-script Z and E on the notation • Note how the notation can be used to represent an atom • Do simple calculations related to isotopic masses and relative atomic masses • Mark their own work • Note how to use orbital box diagram to give electron arrangement of an atom • Use orbital box diagram to illustrate the atom • Study the rubric and ask questions • Design and manufacture a 3-dimensional model of a Chlorine atom to illustrate Bohr's	• Explain the notation $_Z^AE$ and write down what the superscript A and sub-script Z and the letter E represent • Explain how atoms are represented using the notation • Give an exercise that is self-assessed • Explain how to use orbital box diagram to give electron arrangement of elements up to Z = 20 • Give an exercise on orbital box diagram • Explain how to design and manufacture a 3–dimensional model of a Chlorine atom to illustrate the Bohr's model for the structure of an atom • Explain how the rubric (Appendix V) will be used to mark the model • Give each learner a rubric	• Represent atoms (nuclides) using the notation $_Z^AE$	Informal Formal	Formative Diagnostic	Self Teacher	Task-based	
				• Do simple calculations related to isotopic masses and relative atomic masses	Informal Formal	Diagnostic Formative	Self Teacher	Task-based	
				• Give electron arrangement of atoms (up to Z = 20) according to the orbital box diagram (notation, (↑↓))	Informal Formal	Diagnostic Formative	Self Teacher	Task-based	
				• Write **class exercise 2** (Appendix W) based on simple calculation related to isotopic masses and relative atomic masses; and using the notation $_Z^AE$ and orbital box diagram to	Formal	Formative	Teacher	Observation-based	Memorandum

		model		illustrate the atoms (↑↓)					
				• **Project 1**: Design and manufacture a 3-dimensional **model** of a Chlorine atom to illustrate Bohr's model for the structure of an atom	Formal	Formative	Peer Teacher Parent	Task-based	Rubric
13	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	• Peer assess their poster • Defend their position	• Move around and facilitate the process • Spot check learners assessed work	• **Asses the poster using a rubric**	Formal	Formative	Peer Teacher	Observation-based	Rubric (Appendix R)
14	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by	• Learners attentively listen and note what spectroscopic electron configuration is • Write steps to be followed when writing the spectroscopic	• Explain what electroscopic electron configuration notation is • Explain the steps to be followed when writing the spectroscopic electron configuration	• Give electron arrangement of atoms (up to Z = 20) according to the spectroscopic electron configuration notation ($1s^2$, $2s^2$, $2p^6$, $3s^{2,}$	Formal	Diagnostic Formative	Teacher Self	Task-based	

	indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts	configuration of electrons • Do **exercises 3** (see Appendix W) on spectroscopic configuration of electrons • Mark their exercises and do corrections were necessary • Note the diagrammatical representation of orbitals • Study and discuss the orbitals of an atom	• Give **exercise 3** and facilitate the marking thereof • Diagrammatically describe what atomic orbitals are using the Bohr model • Use diagrams to describe the shape of the s-orbital and the p-orbital • Refer learners to pages 154 – 155 of their textbook. • Make learners aware of the orbitals d-orbitals and f-orbitals.	$3p^6$, $4s^2$)					
				• **Exercise 3** (Appendix W) Spectroscopic configuration of Li; N; Ne; and Cl_2	Informal	Formative	Peer	Observation-based	
				• Describe the atomic orbitals	Formal	Formative	Teacher	Task-based	
				• Describe the shape of the s-orbitals	Formal	Formative	Teacher	Task-based	
				• Describe the shape of the p-orbitals	Formal	Formative	Teacher	Task-based	
15	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	• Peer-assess each others' model • Defend their position • Vote for the best model	• Explain the criteria for marking the model • Spot checks the learner's work to ensure reliability and fairness	• **Assess the model**	Informal Formal	Formative	Peer Teacher	Observation-based	Rubric (Appendix V)

16	• Learning Outcome 1 ○ Conduct scientific investigation ○ Collect data systematically, accurately and provide reliable information ○ Seek patterns and trends in information collected ○ Link collected information to existing scientific knowledge ○ Draw conclusion ○ Communicate information and conclusions accurately • **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	• Listen attentively and note important facts with regard to the filling of electrons using Aufbau notation • Write the correct Hund's rule and Pauli's exclusion principle • Apply the rule and the principle to fill the electrons using Aufbau notation • Collect the worksheet • Read the worksheet and discuss amongst themselves • Followed the procedure to execute the experiment • Observe and record • Clean the apparatus • Complete learner self-evaluation form for practical work (Appendix P) • Peer mark their work • Defend their position • Do corrections were necessary	• Explains the Hund's rule • Uses the Aufbau notation to explain how Hund's rule is applied in filling the electrons • States Hund's rule and write it on the chalkboard for learners to see and note • Explains Pauli's Exclusion Principle • Uses the Aufbau notation to explain Pauli's exclusion principle • Observe and correct where necessary • Divide learners into groups • Provide necessary apparatus for practical investigation • Explain the experiment and the procedure to be followed • Complete the observation sheet • Listen to learners' discussions and assist where necessary • Facilitate the marking of the experiment • Ensure that correct answers are written • Complete facilitator evaluation form (Appendix Q)	• State Hund's rule	Formal	Formative	Self Teacher	Task-based	
				• State Paulis Exclusion principle	Formal	Formative	Self Teacher	Task-based	
				• Apply the rule and the principle to fill the electrons using Aufbau notation	Formal	Formative	Teacher	Observation-based	
				• Collect relevant apparatus	Formal	Formative	Teacher	Task-based	
				• Check the apparatus	Formal	Formative	Teacher	Task-based	
				• Demonstration **3** based on colours exhibited by metal cations and metals	Formal	Formative	Teacher	Observation-based	
				• Observe	Informal	Formative	Teacher	Observation	
				• Discuss the outcomes for validity	Informal	Formative	Teacher	Observation-based	
				• Record their findings	Formal	Formative	Teacher	Observation-based	

				• Mark their work	Formal	Formative	Peer Teacher	Observation-based	Memorandum
				• Defend their position and do corrections	Formal	Formative	Teacher	Task-based	
17	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	• Explain what the Periodic Table is • Give the uses of the Periodic Table in Sciences • Listen and note important facts about the Periodic Table • Give the position of elements in the Periodic Table • Give the valence of atoms of some elements • Relate the electronic structure of an element to its position in the Periodic Table • **Library Activity 1**: (Appendix Y) Study and discuss the Periodic Table on pages 160 - 163 • Explain density, melting point, boiling point, and atomic radius • Listen attentively and note important facts with regard to periodicity and density, melting point, boiling point, and the atomic radius • Explain what halides are and give examples	• Explain what the Periodic Table is • Show learners the Periodic Table • Give the uses of the Periodic table in Sciences • Explain how elements are arranged in the Periodic Table • Briefly explain the History of the Periodic Table • Use electron configuration to explain and define the group number of the Periodic Table • Identify groups and give special names given to them • Explain how the group number relates to the valence of an atom of an element • Use electron configuration to explain and define the period number of the Periodic Table • Identify periods and explain how the period number relates to the energy level or quantum number of an element • **Library Activity 1** Request learners to study and discuss the Periodic Table on pages	• Orally explain what the Periodic Table is	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Orally give the uses of the Periodic Table	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain how elements are arranged in the PT	Formal	Formative	Teacher	Task-based	
				• Define the group number of an element in the PT	Formal	Formative	Teacher	Task-based	
				• Define the period number of an element in the PT	Formal	Formative	Teacher	Task-based	
				• Relate the position of an element in the PT to its electronic structure	Formal	Formative	Teacher	Task-based	
				• Relate the electronic structure of an element to its position in the PT	Formal	Formative	Teacher	Task-based	
				• **Library Activity 1** (Appendix Y) Study pages 160 - 162	Informal	Formative	Peer Self Parent	Task-based	

		• Note the periodicity of elements (Li to Ar) with halides and oxides • Do exercises on periodicity of some elements with regard to elements reactions wit halides and oxygen • Assess their attempts	160 – 162 (Kelder, 2008a) (see Appendic Y) • Explain the periodicity of elements with relation to density of elements • Explain the relationship between elements and their melting point, boiling point, and atomic radius • Explain what is the atomic radius • Explain what halides and oxides are • Explain the periodicity of elements (Li to Ar) in terms of their reactions to halogens and oxygen • Assess learners' attempts	• Explain the periodicity of elements (Li to Ar) by looking at the density of an element	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at the melting point of an element	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at boiling point of an element	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at atomic radius of an element	Formal	Formative	Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at the periodicity in formulae of halides	Formal	Formative	Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at formulae of oxides	Formal	Formative	Teacher	Task-based	
				• Give reactions of elements with oxygen and halides	Informal	Formative	Self Teacher	Task-based	
18	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge	• Give the meaning of atomic radius • Write the definitions of the concepts ionization energy, electron negativity,	• Explain the concept atomic radius • Define s and explains the concepts ionization energy, electron affinity, and	• Define the atomic radius	Informal	Diagnostic Formative	Teacher	Task-based	
				• Define ionization energy	Formal	Formative	Teacher	Task-based	
				• Define electron	Formal	Formative	Teacher	Task-based	

	○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	and electron affinity of an element • Note the relationship between periodicity of elements and with the electron affinity and electron negativity of elements • Compare the atomic radius, ionization energy, electron affinity, and electron negativity between the groups and periods • Note the differences in reactivity of group 1, 2, 7, and 8 elements • Account for the difference in reactivity of group 1, 2, 7 and 8 elements respectively • Predict the chemical properties of unfamiliar elements in group 1, 2, 7, and 8 elements • Indicate where metals are found in the Periodic Table • Indicate where non-metals are found in the Periodic Table • Indicate where transition elements are found in the Periodic Table	electron negativity • Explain the ionization energy of elements relative to the periodicity of elements • Explain the relationship between periodicity of elements with the electron affinity and electron negativity of elements • Explain the electronic arrangement to the chemical properties of groups 1, 2, 7, and 8 elements • Describe the differences in reactivity of groups 1, 2, 7, and 8 elements • Give reasons for the differences in reactivity of groups 1, 2, 7, and 8 elements • Explain the chemical properties of unfamiliar elements in group 1, 2, 7, and 8 elements • Indicate where metals, non-metals and transitions elements each are found in the Periodic Table	affinity					
				• Define electron negativity	Formal	Formative	Teacher	Task-based	
				• Explain the periodicity of elements (Li to Ar) by looking at ionization energy of an element	Formal	Formative	Teacher	Task-based	
				• Relate the electronic arrangement to the chemical properties of groups1, 2, 7 and 8 elements	Informal Formal	Diagnostic Formative	Teacher Peer	Task-based	
				• Describe the differences in reactivity of group 1, 2, 7 and 8 elements	Formal	Formative	Teacher	Task-based	
				• Account for the differences in reactivity of group 1, 2, 7, and 8 elements	Formal	Diagnostic Formative	Teacher	Task-based	
				• Predict chemical properties of unfamiliar elements in groups 1, 2, 17 and 18 of the PT	Formal	Formative	Teacher	Task-based	
				• Indicate where metals are to be found on the PT	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Indicate where non-metals are to be found on the PT	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Indicate where the transition metals are to be found on the PT.	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
1	• **Learning Outcome 2** ○ Recall and state	• Give the meaning of the concepts	• Give the definitions of the concepts	• Define the following	Informal Formal	Baseline Formative	Peer Teacher	Task-based	

	basic prescribed scientific knowledge ○ Discussing prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	molecules, mixtures, and compounds • Explain how molecules, mixtures, and compounds are formed • Note the definitions of the concepts chemical bonding, compounds, valence electrons, covalent bonding, ionic bonding, and metallic bonding • **Homework 4** (Activity X) Do activity 12 question 2 number 2 of their textbook (Kelder, 2008a:167)	molecules, mixtures, and compounds • Explain how molecules, mixtures, and compounds are formed • Explain the difference between chemical reaction and mixtures • Explain how chemical reaction is taking place • Define chemical reaction • Give the types of chemical reaction • Define the concept compound and explain how the compound is formed • Explain the concept valence electrons with relation to the group number • Define the concept valence electrons • Give the definition s of concepts ionic bonding and metallic bonding	concepts: molecules, mixture, compound					
				• How are the following substances formed: molecule, mixture, and compounds	Informal Formal	Baseline Formative	Peer Teacher	Task-based	
				• Explain the concept chemical bonding	Formal	Formative	Teacher	Task-based	
				• State the types of chemical bonds	Formal	Formative	Teacher	Task-based	
				• Define the concept compound	Formal	Formative	Teacher	Task-based	
				• Explain what valence electrons are	Formal	Formative	Teacher	Task-based	
				• Explain what covalent bonding is	Formal	Formative	Teacher	Task-based	
				• Explain what ionic bonding is	Formal	Formative	Teacher	Task-based	
				• Explain what metallic bonding is	Formal	Formative	Teacher	Task-based	
				Homework 4 (Appendix X) Do Activity 12, question 2 No. 2 (Kelder, 2008a:167)	Informal	Formative	Self Parent Peer	Task-based	
20	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of	• Peer-mark their homework, defend their positions and do corrections • Write the meaning of covalent bonding • Observe as two learners demonstrate covalent bonding • Write the Lewis dot	• Supervise marking of the homework • Give correct answer • Describe the formation of covalent bond • Draw Bohr's model diagram and Lewis structure to explain covalent bonding	• **Homework 4** Mark activity 12, question 12 number 2 (Kelder, 2008a:167)	Informal Formal	Formative	Self Peer Teacher	Observation-based	Memorandum
				• Describe the formation of covalent bond	Formal	Formative	Teacher	Task-based	
				• Draw the formation of	Informal Formal	Formative	Self Peer	Task-based	

	the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	diagram to demonstrate the simple covalent bonding of • Draw the Bohr model diagram for NH_3 and HCl molecules • Orally name the chemical compounds • Write formulae of covalent compounds • Discuss the properties of giant covalent structures	• Use two learners wanting the same book to demonstrate covalent bonding • Give the correct Bohr model and Lewis dot diagrams for NH_3 and HCl • Use electron diagram to describe the single bond, double bond and triple bond • Explain steps to be followed in naming the covalent compounds • Explain how to write the formulae of covalent compounds in terms of the elements present and the ratio of their atoms using the valency • Give the properties of giant covalent structures	covalent bond of simple covalent molecules			Teacher		
				• Describe using the electron diagrams the formation of single bond of simple covalent molecules	Formal	Formative	Teacher	Task-based	
				• Describe using the electron diagrams the formation of double bonds of simple covalent molecules	Formal	Formative	Teacher	Task-based	
				• Describe using the electron diagrams the formation of triple bonds of simple molecules	Formal	Formative	Teacher	Task-based	
				• Discuss the properties of covalent giant structures	Informal	Formative	Teacher Peer	Task-based	
				• **Library Activity 2** (Appendix Y)**:** Study naming the compounds on pages 176 – 180 and how to write the chemical formulae on pages 199 -200 of Kelder (2008a).	Informal	Formative	Self Peer Parent	Task-based	
21	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge	• Respond to questions of the class test • Mark their exercises • Do corrections	• Give correct names of compounds and correct formulae of covalent compounds • Supervise marking of the class exercise	• **Class Exercise 4** (Appendix W)**:** Write the names of covalent compounds in terms of the	Formal	Summative	Peer Teacher	Test-based	Memorandum

	○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	• Orally explain the concepts valence electrons, valency electrons, ionization energy, and electron affinity • Orally explain what an ion is • Write the meaning of an ion • Explain how ionic bond is formed • Use electron diagram to describe the formation of an ion • Draw the electron diagrams of cations and anions • Note how Periodic Table can be used to determine the ion of an atom • Predict ions formed by atoms of metals using the Periodic Table • Predict the ions formed by atoms of non-metals using Periodic Table • Name the ionic compounds based on the component of an ion • Write the Lewis structure to illustrate the formation of ionic bonds and name the substances formed; sodium and oxygen potassium and	• Explain the concepts valence electrons, valency electrons, ionization energy, and electro affinity • Use electron diagrams to explain how ions are formed • Use electron diagrams to explain the formation of cations and anions • Explain how to use the Periodic Table to predict ions formed by atoms of metals and non-metals • Explain how to use the components of a compound to name the ionic compound	elements present and formulae of covalent compounds in terms of the elements present and the ratio of their atoms					
				• Explain the following concepts: valence electrons, valency electrons, ionization energy, and electron affinity	Informal Formal	Baseline	Peer Teacher	Task-based	
				• Explain what the ion is	Formal	Formative	Teacher	Task-based	
				• Describe, using electron diagrams, the formation of ions	Formal	Formative	Teacher	Task-based	
				• Describe, using electron diagrams, the formation of ionic bonds	Formal	Formative	Teacher	Task-based	
				• Draw the electron diagrams of cations	Formal	Formative	Teacher	Task-based	
				• Draw the electron diagrams of anions	Formal	Formative	Teacher	Observation-based	

		chlorine; aluminium and fluorine		• Predict the ions formed by atoms of metals and non-metals using information in the PT	Informal	Formative	Peer	Task-based	
				• Name ionic compounds based on the component ions	Formal	Formative	Teacher	Task-based	
				• **Homework 5**: (see Appendix X) Give the Lewis structure to illustrate the formation of ionic bonds and name the substances formed for: sodium and oxygen; potassium and chlorine; aluminium and fluorine	Informal	Formative	Self Peer Parent	Task-based	
22	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information	• Peer-asses their homework • Do corrections • Describe the structure of an ionic crystal • Describe the simple model of metallic bonding • Note the meaning of inter-molecular and intra-molecular forces • Discuss the names of cations and anions as indicated on the Tables • Discuss and write the names of different compounds • Give the relative atomic mass for covalent molecules	• Give the Lewis structure to illustrate the formation of ionic bonds and name the substances formed for: sodium and oxygen potassium and chlorine • Describe using examples the structure of an ionic crystal • Explain the concept inter-molecular and intra-molecular forces • Explain the simple model of metallic bonding • Request learners to study cations and anions table • Move around, observe and listen to learners' discussion of atomic	• Give the Lewis structure to illustrate the formation of ionic bonds and name the substances formed; sodium and oxygen; potassium and chlorine; aluminium and fluorine	Informal	Formative	Peer	Observation-based	Memorandum
				• Describe the structure of an ionic crystal	Formal	Formative	Teacher	Task-based	
				• Describe the simple model of metallic bonding	Formal	Formative	Teacher	Task-based	
				• Study and discuss the cation and anion table	Informal	Formative	Peer	Task-based	

		• Write the relative formulae mass for ionic compounds	mass and relative formulae for ionic compounds.	• Write the names of compounds	Informal	Formative	Peer Teacher	Observation-based	
				• Give the relative molecular mass for covalent molecules	Informal	Formative	Peer	Task-base	
				• Write the relative formula mass for ionic compounds	Informal	Formative	Peer	Task-based	
23	• **Learning Outcome 2** ○ Recall and state basic prescribed scientific knowledge ○ Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other ○ Apply scientific knowledge in familiar, simple contexts ○ Categorise information ○ Find information from other sources	• Write correct answers to the questions stated • Mark a partner's test • Defend position and do correction • Reflect on the attainment of Learning outcomes and Assessment Standards • Reflect on own learning • Study a checklist	• Give **summative test 2** on selected parts of matter and materials • Write correct answers on the chalkboard • Supervise the peer assessment of test • Give feedback • Create opportunity for the class to reflect on learning during the past cycle - Use a thick coloured pen to tick off on the checklist on the wall all the Assessment Standards that have been attained • Allow time for learners to reflect on their own learning and progress by completing the form in their files (see Appendix M) • Share learning objectives for the next cycle with learners • Give homework • Take note of learners' • Feedback on their learning and review your teaching in order	• Write correct answers to the questions of the test	Formal	Summative	Peer	Test-based	Memorandum
				• Mark peer's test script	Informal	Formative	Teacher	Observation-based	
				• Do corrections	Informal	Formative	Teacher	Observation-based	
				• As a group, reflect on the attainment of Assessment Standards and tick them off	Formal	Formative	Self, Peer Teacher	Observation-based	
				• Reflect on own learning by completing the form (see Appendix M)	Informal	Diagnostic formative	Teacher	Observation-based	
				• Study the checklist and rating scale and orally answer questions randomly asked by the teacher on the criteria	Informal	Formative	Teacher	Observation-based	

			to become effective	**Homework activities** • Study waves, sound and light and answer the following questions: - Define a pulse - Define a transverse pulse - Define amplitude - Explain superposition of pulses	Informal	Formative	Self Parent Peer	Task-based	Memorandum and rating scale

10.5 Practical implementation of the model for Outcomes-Based Assessment of Grade 10 Physical Sciences in the FET band

In order to make implementation of the assessment model easier, more information is provided on how the model should be practically implemented in the classroom. Although assessable tasks and assessable tools are planned prior to teaching and learning activities in the initial stage of lesson planning, the model for assessment follows the logical execution procedure in the classroom. Thus, although design-down is followed in the planning of the lesson, the execution of the lesson is still in the logical sequence. Assessable tasks come at the end of the lesson; they are the product or outcomes of the teaching and learning that have taken place (Reyneke, 2008:199).

The assessment model is based on the Physical Sciences learning outcomes, teaching strategies, learning activities and assessment. The three Physical Sciences learning outcomes address the scientific inquiry and problem solving skills in a variety of scientific, technological, socio-economic and environmental contexts; the construction and application of scientific and technological knowledge; and understanding of the interrelationship between Physical Sciences, technology, society and the environment and of different attitudes, values, knowledge and skills which should be taught and learned in an integrated way. It should be noted that the skills, knowledge, attitudes and values for Physical Sciences are embedded in the LOs and ASs. LOs describe what the learner should achieve and Assessment Standards describe what a learner should know and be able to demonstrate (i.e. skills, knowledge, attitudes and values) by the end of each grade (DoE, 2005b:8). Skills, knowledge, attitudes and values are interwoven with Physical Sciences teaching and learning and are therefore embedded in the LOs and ASs. For this reason no specific cognitive, affective and psychomotor outcomes were identified and/or formulated for each lesson.

The project deals specifically with the practical implementation of the assessment model, and it is therefore taken as a given that the phases of each of the lesson below will be put into place. The phases referred to are the introductory phase where the teacher shares the learning outcomes for the lessons, where the teacher creates the context for learning and makes sure that the outcomes are linked with prior learning in a meaningful way, the teaching, learning and assessment phase, and the final phase where consolidation and reviewing of learning takes place.

The following are important matters that should be addressed during the first days of the new school year (Lessons 1 – 3):

- A classroom policy should be drawn up by the teacher and the learners to ensure that everybody knows exactly what is expected in terms of classroom discipline, teaching, learning and assessment.
- The teacher should also present learners with a list of Laboratory Safety Rules (see Appendix J). Rules should be discussed with learners and parents should sign them so there are no surprises later on. Learners should keep rules in the front of their files as constant reminder. The teacher should also have them displayed in the laboratory where they can be read by everybody who enters the laboratory.
- In addition to a list of laboratory rules, an information sheet (see Appendix L) that learners complete with their name, parent(s) name, address, home and work phone numbers, and e-mails is valuable. A space should be left for learners to state special needs (e.g. sitting arrangements, sensitivity to strong chemical smells, allergies, reactions or ailments).
- An overview should be given of the LOs for the year. Reyneke (2008:200) suggests that it is a good idea to put an enlargement of the checklist for ASs up against the classroom wall (see Appendix I). At the end of each learning cycle, the accomplished unit should be ticked off to give learners a sense of achievement and success.
- There are symbols in the laboratory to warn users of certain dangers they might encounter if they do not behave appropriately or use some chemicals inappropriately. There are also other symbols to give users an idea of protective or corrective measures to take in case of hazards. For these reasons, learners must be able to identify the symbols and understand their meaning. Appendix K shows some examples of symbols learners may encounter in the laboratory.

Orientation of Grade 10 learners (Lesson 1 – 3) (Optional)

Lesson 1: Wednesday 11 January 2012 (First day of the new school year)

Lesson outcome: Promote organisational behaviour

In order to attain the above outcome, the following activities will be conducted:

- Informally introduce the class rules.
- Vote for the class rules and sign for it.
- Complete the information sheet and sign it.

The teacher makes sure that all the learners understand the class rules and promise to abide by them. Each learner receives a copy. Each learner also receives a learner's personal information sheet where he/she has to furnish the necessary information (Appendix L). Learners who cannot furnish all the necessary information, must be given the information sheet to complete at home and bring back the following day.

This is evident when learners are capable of:

- Rehearsing the class rules;
- Giving the importance of abiding by the rules;
- Telling what steps have to be taken when a learner does not abide by the rule;
- Signing the class rules;
- Completing and signing the learner information sheet.

Lesson 2: Thursday 12 January 2012

Lesson outcome: Promote safety in the laboratory

In order to attain the above outcome, the following activities will be conducted:

- Escort the learners to the laboratory.
- Explain the use of the laboratory.
- Show learners the emergency exit and explain when to make use it.
- Show learners the eye wash station, when and how to use it.
- Show learners the safety shower, when and how to use it.
- The teacher will show the learners the safety equipment (first aid box, fire extinguisher, fire blanket, etc), their location and how to use them.
- Show learners where chemicals are stored and explain why chemicals are arranged that way.

Lesson 3: Friday 13 January 2012

Lesson outcome: Promote laboratory safety

In order to attain the above outcome, the following activities will be performed:

- Wearing the laboratory safety outfit, the teacher will orally introduce the laboratory rules.

- The teacher explains why it is necessary to adhere to the rule.
- When rules are agreed upon, the teacher should write the rules and have them displayed in the laboratory where they can be read by all learners (Appendix J).
- The teacher will also show, name and explain the meaning of each of the laboratory safety symbols or signs (Appendix K).

TEACHING AND LEARNING CYCLE 1

Knowledge Area: Matter and Materials

Duration: 16 January 2012 until 10 February 2012 (20 lessons of ±40 minutes each)

In preparation for the first formal lesson on Monday 16 January 2012, the teacher has the task to ensure that the concepts and skills necessary for further studies are in place. Therefore, each learner must revise the following:

- Matter and its classification

The teacher ensures that all the learners know where they can find the information and how to access this information. Each learner receives a checklist (see Appendix I). The checklist is based on the Assessment Standard and is discussed so that each learner knows exactly what is expected of him/her. In order to promote learner participation in the learning and assessment process, the teacher and the learners may decide together how many ticks in the Yes/No columns of the checklist will be needed for a performance to be rated Good, Average or Poor.

Planning and the development of the lesson will follow the teaching-learning model (see Figure 10.1), which is aimed at the achievement of learning outcomes.

Lesson 4: Monday 16 January 2012-02-10

Lesson Outcomes:

- Orally introduce the content of knowledge area Matter and Materials.
- Explain the concept matter/material.
- Give the properties of matter.
- Explain the types of mixtures.
- Explain the properties of homogeneous and heterogeneous mixture.

The teacher introduces the learners to the contents of the knowledge area “matter and materials” for the next five (5) weeks and shares the learning outcomes with them. In order to attain certain ASs that will later be ticked off on the checklist against the classroom wall, learners need to demonstrate in-depth knowledge, application skills and positive attitudes and values concerning the learning and teaching of the learning area Matter and Materials and in particular the following content areas:

- Matter and classification
  - Materials
  - Mixtures: heterogeneous and homogeneous
  - Pure substances
  - Names and formulae of substances
  - Metals, semi-metals and non-metals
  - Electrical conductors, semi-conductors and insulators
  - Thermal conductors and insulators
  - Magnetic and non-magnetic materials
- States of matter and the kinetic molecular theory: Atomic structure
  - Models of the atoms
  - Atomic mass and diameter
  - Protons, neutrons and electrons
  - Isotopes
  - Energy quantisation and electron configuration in groups
- Chemical bonding
  - Covalent bonding
  - Ionic bonding
  - Metallic bonding
- Particles substances are made of
  - Atoms and compounds
  - Molecular substances, and
  - Ionic substances

It is important that the teacher informs the learners about the integration of the learning content with other subjects.

Teaching activities

- Learning outcomes are discussed with the learners.
- Give each learner a form to set learning goals.
- Orally the teacher introduces the topic “matter and materials” and asks learners to give their definition of the concept “matter”, give examples and give the properties of matter.
- Write on the chalkboard the definition of the concept “matter” and examples given by learners.
- Explains what homogeneous and heterogeneous mixtures are.
- Asks learners to classify the given substances as heterogeneous and homogeneous.
- Refers learners to the homework they should do.

Learning activities

- Learners complete the first part of the form on which they set personal aims for the learning cycle and later reflect on their learning.
- Learners get the opportunity to orally define and give examples of matter.
- Learners orally define the concept mixture, homogeneous and heterogeneous.
- Differentiate between homogeneous and heterogeneous mixtures.
- Note the properties of homogeneous and heterogeneous mixtures.
- Learners are given the opportunity to discuss further examples of homogeneous and heterogeneous mixtures given on tables (Kelder, 2008a:128).
- Learners write **exercise 1** (Appendix W), where they classify the given substances as homogeneous and heterogeneous. The work is **self-assessed** (Appendix W).
-

Assessment

- The teacher simply listens to learners while using **baseline assessment** to establish what they already know about matter and mixtures, and uses **formative assessment** when learners are kindly assisted with the scientific definitions. The teacher gives constructive oral **feedback**.

- The teacher simply observes and listens to learners’ discussions while using **diagnostic assessment** to establish learners’ learning barriers and **formative assessment** when learners are kindly assisted with concepts they misunderstand.

- Informal **self-assessment** takes place when the learners critically listen to answers given by fellow learners and compare their answers with his/her answer. **Formative** assessment takes place when the teacher writes the correct answers on the chalkboard for learners to see (Appendix W). **Informal formative assessment** takes place when learners mark their own work and do corrections where necessary. Finally, the learner rates his/her work as good, average or poor (see Appendix N for the rating scale).

- **Feedback** should be constructive and must focus on the merits of correct answers and general errors that should be brought to learners' attention so that they can try and eliminate these in future.

- It is important to have some system in place so that learners who do well can be praised and given some rewards, like stamps or stickers that are pasted in their books by the teacher. Once a certain number of stickers have been collected by the learner, (as agreed by the class) a larger reward can be given. Larger rewards may mean something as simple as entering the learner's name on a special list on the classroom wall or by giving him/her a chocolate bar or cold drink. This will motivate learners to work harder every time.

Lesson 5: The lesson outcomes are:

- Recognise different mixtures in your home and environment.
- Distinguish between elements and compounds as pure substances.
- Observe phenomena, describe concepts, classify and use materials (macroscopically).
- Plan an investigation by suggesting possible actions to separate the dye colours.
- Record experimental results logically and scientifically.

As each learner enters the laboratory the teacher calls out a number between 1 and 4. Once inside the laboratory learners sharing the same number are told to form a group. This means that in a class of 40 learners, there will be 10 groups of four learners each.

Teaching activities

- Orally explain what elements and compounds are.
- Write the definitions of concepts elements and compounds.
- Distinguish between elements and compounds.
- The teacher outlines the expected outcomes of the experiment.

- The teacher ensures that appropriate material and apparatus are in order.
- The teacher discusses the experiment with the learners and gives them instructions for the experiment.

Both, the teacher and the learners go through worksheet 1 (see Appendix O) to ensure that everyone understand what is to be done.

Learning activities

- Give examples of metals and compounds.
- Write the correct definitions of elements and compounds.
- Note the differences between elements and compounds.
- One member from each group collects the experiment worksheet (see Appendix O for the worksheet) and the apparatus to do the experiment.
- Learners follow a series of questions and instruction on the worksheet.
- They perform the activities, observe and record experimental results on the spaces provided on the worksheet.

Assessment

- **Informal formative assessment** takes place when learners explain what elements and compounds are and give the examples. **Formal formative assessment** is applied when the teacher gives feedback to learners' responses.
- The teacher moves around to observe, listen and give directives to learners. He/she uses **formative assessment** in assisting learners with the interpretation of concepts and corrects execution of the experiment. The teacher can also use the observation sheet (Appendix T) to assess learners' participation during the execution of the experiment.
- Knowledge, values and skills (i.e. observation, measuring, recording, manipulation, inference, procedure, investigation, and evaluation) are formally assessed when learners execute the experiment.
- **Formative assessment** takes place when the learner completes the self-evaluation form (Appendix P) on conclusion of the practical.
- Again the teacher uses **formative assessment** by making use of the memorandum to mark the experiment (Appendix O).
- **Formative assessmen**t and **diagnostic assessment** take place when the teacher completes the facilitator evaluation form (Appendix Q).

It is important for the teacher to complete the facilitator evaluation form because it makes it easier for the teacher to identify specific skill deficiency. Identified problems can be remedied.

Homework activity

- Learners identify 6 mixtures in their homes.
- Write down the ingredients that each one contains.
- Find out in what phase the ingredients normally exist.
- Are they safe to use?
- Do they affect the environment adversely?
- Why are they added to the product?
- Learners are advised to use a selection of body cleaning and beautifying products, food products in tins, frozen or in packets, and household cleaners. The results should be presented in a table.

Assessment

Each learner is given a copy of the checklist that will be used to formally peer-assess the tabulated results. The rubric must be thoroughly explained to the learners and the teacher must check that they know exactly what is expected of them. If the time allows, the teacher and learners may design the rubric together by selecting assessment standards from the checklist.

LESSON 6

Lesson Outcomes:

- State opinion and defend the position.
- State the properties of metals, metalloids and non-metals.
- Classify substances as metals, metalloids and non-metals.
- Test and classify substances as electrical, thermal conductors and magnetic.
- Identify the position of metals, metalloids and non-metals in the periodic table.
- Observe phenomena, describe concepts, classify and use materials (macroscopically).
- Plan an investigation by suggesting possible actions to differentiating amongst materials.
- Record experimental results logically and scientifically.
- Explain the use of the properties of metals at home.

On entering the laboratory, learners are divided into groups by being given the numbers, worksheet 2 (Appendix R) and been assigned to a laboratory table with the necessary apparatus. The teacher might opt to group learners according to their ability, remediation, or mixed-ability groups.

Once seated, learners are requested to exchange their homework books for assessment.

Assessment

- Before **peer-assessment** commences, the criteria should be explained again.
- **Informal Formative assessment** for the task 'Recognising different mixtures in your home and environment' is **peer-assessed** using the checklist (Appendix N).
- **Formative assessment** takes place when the learners use the checklist and finally rate each others' work as good, average or poor (see Appendix N for the checklist and rating scale).
- **Formative assessment** takes place when the partners write down suggestions on the checklist on how to improve each others' performance.
- The teacher observes and listens to learners' responses while using **baseline assessment** to establish what learners already know and can do, and a **formative assessment** when learners are assisted with correct ingredients, their phase, safeness, effect to environment and their use, and also when learners are assisted in assessing each others' endeavour. The teacher gives constructive **feedback**.

After all the necessary experimental instructions are given, learners start with the execution of the experiment. Only activities A - C of the worksheet are completed for this lesson.

Teaching activities

- The teacher explains and states the properties of metals, metalloids and non-metals while giving examples and showing pictures.
- Correct explanations and examples of metals, metalloids and non-metals are written on the chalkboard.
- The teacher explains how apparatus may be used to test substances for the electrical conductivity, thermal and insulation abilities.
- The results of the experiment are explained by the teacher.

Learning activities

- Learners orally respond to teacher's questions with regard to metals, metalloids and non-metals.
- Orally explain what electrical conductors, thermal conductors and magnetic materials are.
- Orally propose how materials may be used to test substances for the electrical, thermal conductivity, and magnetism.
- Learners test and complete worksheet 2 (see Appendix R) by classifying substances as electrical, thermal conductors and insulators, and magnetic.
- Identify the position of metals, metalloids and non-metals in the periodic table.
- Observe phenomena, describe concepts, classify and use materials (macroscopically).
- Plan an investigation by suggesting possible actions to differentiating amongst materials.
- Record experimental results logically and scientifically.
- Discuss the use of the properties of metals at home.

Assessment

- The teacher uses **baseline assessment** by asking learners to give examples of metals, metalloids and non-metals they know. **Informal formative assessment** takes place when responses are also **peer-assessed** as peers are given a chance to comment on their counterparts' responses. By listening to the learners' responses and inputs, **baseline and formative assessment** are being applied as well.
- **Formative assessment** also takes place when the teacher gives correct scientific concepts and shows learners examples of pictures of metals, metalloids and non-metals.
- **Formative assessment** continues when the teacher walks around, observes and listens to discussions during practical work, and when he/she assists with correct manipulation of apparatus. The observation sheet (Appendix T) can also be used by the teacher during practical work to **formatively assess** the learners' participation and manipulation of apparatus.
- **Informal formative assessment** takes place when learners complete the self evaluation form (Appendix P).
- **Informal formative assessment** takes place when the peer uses the memorandum to mark the other learners' experimental work. **Formative assessment** continues when the teacher discusses the answers on the memorandum. **Remediation** also takes place when the teacher addresses certain learning barriers.
- **Formative assessment** continues to take place when the teacher completes the facilitator's evaluation form (Appendix Q).
- The teacher uses **formative and diagnostic assessment** while learners use the properties of metals,

metalloids and non-metals to indicate their position on the Periodic Table.

- Further **formative assessment** takes place when learners explain the uses of the properties of metals at home. **Informal formative assessment** takes place when learners apply **peer assessment** by commenting on their **peers'** responses. The teacher's clarifications are also referred to as **formal formative assessment**.

Lesson 7

Lesson outcomes are:

- Classify materials as magnetic and non-magnetic.
- Give examples of the use we make of magnets in our daily life.
- Explain diffusion of potassium permanganate in water and define the concept diffusion.
- List and characterise the three states of matter.
- Define freezing, melting, and boiling points of water.

Teaching activities

- The teacher explains what magnetic and non-magnetic materials are, and further explains how to investigate the magnetic properties of solids materials.
- He/she further explains the uses we make of magnets in our daily life.
- The teacher explains what diffusion is and he/she further demonstrates the diffusion of potassium permanganate in water.
- The teacher asks the learners to state the form in which matter may exist and lists their characteristics.
- The teacher explains what the freezing, melting, and boiling points of water are.

Learning activities

- Learners verbally respond to teacher's questions with regard to magnetic and non-magnetic materials.
- Learners use strategies to classify magnetic and non-magnetic materials.
- Learners discuss and give example of the uses we make of magnets in our daily life.
- Learners observe and record the behaviour of potassium permanganate in water.
- Learners explain what they understand about the freezing, melting and boiling points of water. They copy the correct definition on their workbooks.

Assessment

- The teacher uses **baseline assessment** when he finds out from learners what they think magnetic and non-magnetic materials are, and continuous to use **formal assessment** when he/she gives the correct explanation of metal and non-metals of the materials.
- **Informal formative assessment** takes place when other learners comment on their counterparts' responses. **Formal formative assessment** takes place when the teacher clarifies, supplies the correct scientific meanings and writes it on the chalkboard.
- **Informal formative assessment** continues to take place when learners discuss and argue about the methods they could use to separate magnets from non-magnetic substances. The teacher uses **diagnostic and formative assessment** when he walks around and listens to learners' discussions and make corrections were necessary.
- **Formal assessment** takes place when learners record their observation on the worksheets.
- **Informal formative assessment** continues when learners explain the behaviour of potassium permanganate dissolution in water, and **formative assessment** happens when the teacher gives the scientific explanation and correct definition of the process.
- **Informal and baseline assessment** takes place when learners explain what they understand under the concepts, freezing, melting and boiling point of water and **formal formative assessment** when the teacher gives the correct definition of the concepts.
- **Feedback** on learners' responses by the teacher is **formative assessment**.

Lesson 8

Lesson Outcomes:

- Respond to questions.
- Defend the responses.
- Do corrections.
- Rate each other.

Teacher activities

- Questions of the test are written on the chalkboard.
- The teacher moves around and observes as learners write answers to the questions of the test.

- Gives correct answers and writes the memorandum on the chalkboard for learners to see.
- Ensures that correct answers are written by looking at learners' books.

Learner activities

Write the answers to the questions of the test.

Assessment

- **Formative assessment** takes place when learners respond to the question of the test.
- **Formative and diagnostic assessment** takes place when the teacher uses the memorandum to mark the learners' test books. **Formative assessment** continues when the teacher discusses the answers in the memorandum. Learners are given a chance to defend their responses. **Remediation** also takes place when the teacher addresses certain learning barriers.

Lesson 9

Lesson outcomes are:

- Observe and define the concepts sublimation.
- Identify the physical state of a substance at a specific temperature, given the melting, boiling and freezing point of substance.
- Observe and draw the graph of the phase change of water.

Teaching activities

- The teacher explains what sublimation is and demonstrates the sublimation of iodine.
- The teacher explains how to use the specific temperature of a substance to identify its physical state given the melting, boiling and freezing points of a substance and ask learners to study the topic on melting and boiling points of some substances in their textbook.
- The teacher groups learners and gives each group worksheet 3 and relevant apparatus to conduct experiment 3 (see Appendix S) of the phase change of water starting from water as ice.

Learner activities

- Learners give their thinking about what sublimation is and suggest examples of substances that they think sublimes.
- They study and discuss melting points and boiling points of substances in their textbooks.
- Learners perform the experiment (Appendix S), observe, tabulate the results and plot the graph of temperature versus time for the phase change of water.

Assessment

- **Informal formative assessment** takes place when learners give their thinking about what they think sublimation is and provide examples of substances that sublime. The teacher uses **formal formative assessment and baseline assessment** to find out what learners know about the concept sublimation. **Informal formative assessment** also takes place when learners comment on their fellow learners' responses.
- **Formative assessment** takes place when the teacher corrects and gives a scientific explanation of the concepts.
- **Informal formative assessment** takes place when learners argue about the melting points and boiling points of substances and **formal assessment** when the teacher gives the correct information.
- The teacher simply observe and listen to learners' discussion while using **diagnostic assessment** to establish learners' learning barriers and **formative assessment** when learners are kindly assisted with concepts they misunderstand and the manipulation of the apparatus.
- **Formal formative assessment** takes place when learners tabulate the results of the experiment and plot the graph.
- The teacher uses **formative assessment** when he uses the checklists and memorandum to mark learner's table and graphs and continues when the teacher discusses the results of the experiment with the learners in class.

Lesson 10

Lesson outcomes are:

- Describe the states of matter according to the Kinetic Molecular Theory.
- Give a rough estimate of the mass and diameter of an atom.
- Match the discovery with the description of the atom that followed the discovery.

Teaching activities

- The teacher explains the following concepts giving real life examples: density, kinetic energy of particles and change in temperature, melting and boiling, viscosity and thermal expansion, and conduction of heat in metals and non-metals using the Kinetic Molecular Theory.
- The teacher makes it clear to learners that the phase in which a substance exists, depends on the intermolecular forces and the kinetic energy of the particles.

Learning activities

- Learners write down the important points and respond to questions based on concepts and factors related to the Kinetic Molecular Theory.
- Research the life of a chosen scientist with attention to the contribution that scientist made to the atomic theory and prepare and display a poster. The poster will be assessed by the teacher and the class members.

Assessment

- The teacher uses **baseline assessment and formative assessment** to find out what learners know about the Kinetic Molecular Theory of a substance. **Formal formative assessment** continues to take place when the teacher listens to learners' responses and gives the correct scientific concepts. Correct concepts are written on the chalkboard for learners to copy.
- **Formal Formative assessment** takes place when the learners' posters are **assessed by peers** and the teacher using the rubric each learner has received.
- **Formative assessment and diagnostic assessment** take place when the teacher provides learners with the necessary tips to improve the poster.
- **Informal formative assessment** also takes place when peers suggest what learners can do to improve their work.

- The teacher gives **feedback** by giving a summary of the contributions of the scientist to the development of an atom.

Library Assignment

- The teacher allocates each learner a scientist to research and gives guidelines on how to design a poster.

Assessment

- Each learner receives a copy of the assessment rubric that will be used to formally **peer assess** the designed poster of the contribution of a scientist to the development of an atom. Criteria on the rubric are based on relevant assessment standards and must be stated in such a way that learners thoroughly understand what it means. The poster will be **peer-assessed** during the 13th lesson to give learners enough chance to research and find time to design a poster.

Lesson 11

Lesson outcomes are:

- Describe and use the concept relative atomic mass.
- Describe and use the concept mass number.
- Describe how atoms are arranged in solids, liquids, and gases.
- Give the number of protons, electrons present in the neutral atom of the element.
- Determine the charge of an atom after removing electrons from the atom.
- Calculate the mass number for an isotope of an element.

Teaching activities

- The teacher orally finds out from learners what they understand by the concepts relative atomic mass and mass number.
- The teacher then gives the correct scientific explanation of the concepts, and writes the correct definitions on the chalkboard for learners to copy.
- The teacher uses a Styrofoam sphere and a cardboard to demonstrate and describe how atoms are arranged in solids, liquids and gases substances.

- The teacher responds to learners' questions.
- The teacher uses diagrams to explain the composition of a neutral atom while he asks learners to give the charges of particles electron, protons and neutrons.
- Using the atomic number, the teacher shows learners how to determine the charge of an atom when the electron is removed from the atom.
- The teacher uses the isotopes of Hydrogen to show learners how to calculate the mass number for an isotope of Hydrogen and other elements.

Learning activities

- Learners verbally respond to the questions based on the relative atomic mass and the mass number.
- They copy the correct scientific definition of the concepts in their notebooks.
- Learners observe and note what they have observed. They ask questions where they do not understand.
- Other learners respond to questions raised by the fellow learners and the teacher.
- Learners verbally respond to the teacher's questions based on the composition of an atom.
- Learners follow the example and answer questions that the teacher asks thereafter.

Assessment

- **Baseline assessment** is used when the teacher listens to learners' verbal responses and establishes what they know.
- **Summative assessment** takes place when the teacher gives the correct scientific concepts and writes the correct concepts on the chalkboard. The teacher moves around to check if correct concepts are written.
- **Formal formative assessment** continues when the teacher responds to learners questions during demonstration with Styrofoam balls.
- A summary of the arrangement of atoms in solids, liquids and gases substance is written on the board or projected to the screen using the OHP.
- **Informal formative assessment** takes place when learners give the charge of electrons, protons and neutrons
- **Formative and diagnostic assessment** takes place when learners give the charge of an element when the element has lost an electron.
- **Formative and diagnostic assessment** takes place when learners calculate the mass number of an atom.

Lesson 12

Lesson outcomes are:

- Represent atoms (nuclides) using the notation $_Z^AE$.
- Do simple calculations related to isotopic masses and atomic masses.
- Give electron arrangement of atoms (up to Z = 20) according to the orbital box diagram (notation (↓↑).
- Design and manufacture a 3-dimensional model of a chlorine atom to illustrate Bohr's model for the structure of an atom.

Teaching activities

- The teacher uses the notation $_Z^AE$ to show learners how to represent atoms, taking Nitrogen and Helium as examples.
- He asks learners to do the same for Sodium and Magnesium ion.
- The teacher explains what an orbital box diagram is and draws the diagram on the chalkboard.
- He/she further uses the orbital box diagrams to distinguish between the s-orbital and p-orbital and how electrons are drawn in each box. Helium and Nitrogen atoms are used as examples.
- Together, the teacher and the learner read and discuss the general rules for filling the orbital diagrams as stipulated in Kelder, 2008a:155.

Learning activities

- Learners discuss and write down the examples.
- Discuss and write the correct notation.
- Learners follow the examples the teacher used for Helium and Nitrogen to write orbital box diagrams for Sodium and Magnesium atoms.

Assessment

- While learners discuss the representation, the teacher **moves around and critically observes and assesses** the learners' work and helps those who encounter difficulty.
- Having written the correct notation on the chalkboard, learners **formally self-assess** their work and make corrections where necessary.
- Learners **mark their own answers** to the orbital box diagram for neutral atoms of Sodium and Magnesium exercise while the teacher leads the marking by sharing the answers from the memorandum that is written on the chalkboard. It is necessary for learners to see the answers and be given the opportunity to defend their answers and make the necessary corrections as part of the **formative assessment**.
- Each learner receives a copy of the assessment rubric (Appendix V) that will be used to formally peer assess the designed 3-dimensional model of a chlorine atom. Criteria on the rubric are based on relevant assessment standards and must be stated in such a way that learners thoroughly understand what it means. The model will be assessed during the 15th lesson to give learners enough chance to research and find waste material for the model.

Lesson 13

Lesson outcomes are:

To assess the poster using a rubric (Appendix U),
To defend a position.

Assessment

- Before **peer-assessment** starts, the teacher needs to explain the criteria again for everyone to understand and ask questions where necessary.
- Learners work in pairs and **peer-assess each others'** poster while the teacher moves around to facilitate the process. Each individual may argue his/her results, while the assessor must be able to defend the rating given. **Spot checks** are done by the teacher to ensure that **the assessment is fair and reliable**. The results may be used in a **formative way**, enabling learners to improve their results, if they wish. Learners who do not meet the criteria in a satisfactory way must be given an extended opportunity to learn.

Lesson 14

Lesson outcomes are:

- Give electron arrangement of atoms (up to Z = 20) according to the spectroscopic electron configuration notation ($1s^2$, $2s^{2,}$ $2p^6$, $3s^2$, $3p^6$, $4s^2$).
- Describe the atomic orbital.
- Describe the shape of the s-orbital and the p-orbital.

Teaching activities

- The teacher explains what spectroscopic electron configuration notation is he/she further explains the steps to follow while using a Sodium atom to write its spectroscopic electron configuration notation as an example.

  e.g. Step 1: use the Periodic Table to find the atomic number of an element ($_{11}NA$).

  Step 2: assign the atomic number to the given element (Na = 11).

  Step 3: When the atom of an element is neutral, then the atomic number equals the number of the electrons of the atom of an element (e^- = 11).

  Step 4: Write the spectroscopic electron configuration.

  [Na] $1s^2$ $2s^2$ $2p^6$ $3s^1$
- The teacher gives learners more exercises.
- The teacher uses the diagram to describe the atomic orbital of Hydrogen atom. He/she explain the atomic model as the region of probability where electron can be found.
- The teacher uses the diagrams to describe the shapes of the s-orbitals and p-orbitals. He/she refers learners to study pages 154 – 155 of their prescribed textbook (Kelder, 2008a) which shows and explains the shape of the orbitals. Learners are made aware of other orbital like the d-orbitals and f-orbitals.

Learning activities

- Learners listen critically as the teacher explains what spectroscopic electron configuration is and take notes.
- They follow the steps explained by the teacher to write the spectroscopic electron notation for a neutral Sodium atom and other elements given by the teacher.
- They continue to listen critically when the teacher describes the shapes of the s-orbitals and the p-orbitals and take notes.

- Learners study and discuss the shapes of the s-orbitals, p-orbitals, d-orbitals, and the f-orbitals from their textbooks.

Assessment

- **Informal formative assessment** takes place when the teacher answers learners' questions with regard to spectroscopic electron configuration.
- **Diagnostic and formative assessment** takes place when learners follow the steps given by the teacher to write the spectroscopic electron notation for a neutral Sodium atom. **Informal formative assessment** is evident when learners use the memorandum to mark their own work. The memorandum is written on the chalkboard for learners to see and learners are given the opportunity to defend their responses and mark their work for **formative assessment.**
- The teacher walks around and observes and listens for discussions as part of assessing whether the learners understand what they are studying.

Lesson 15

Lesson outcomes are:

To assess the model using a rubric (Appendix R);
Learners defend a position.

Assessment

- Before **peer-assessment** starts, the teacher needs to explain the criteria again for everyone to understand and ask questions where necessary.
- Learners work in pairs and **peer-assess each others' model** while the teacher moves around to facilitate the process. Each individual may argue his/her results, while the assessor must be able to defend the rating given. **Spot checks are done by the teacher to ensure that the assessment is fair and reliable**.

Lesson 16

Lesson outcomes are

- State Hund's rule.
- State Pauli's Exclusion principle.
- Give the colours exhibited by some metal cations and metals.

On entering the laboratory, learners are divided into groups using the appropriate technique. Each group is given the worksheet for the **experiment** on the colours exhibited by some metal cations and metals.

Teaching activities

- The teacher explains Hund's rule and uses the orbital box diagram (Aufbau notation) to explain how the rule is applied in filling the orbitals with electrons.
- The very same procedure as above is followed to explain Pauli's Exclusion Principles.
- The teacher writes Hund's rule and Pauli's Principle for learners to see and to be able to recall.

Learning activities

- Learners listen attentively as the teacher explains Hund's rule and Pauli's Principle and take notes.

Learning and assessment

- Learners apply Hund's rule and Pauli's principle to fill the orbitals of the given elements with electrons.

Assessment

- The teacher **walks around and observes** as learners apply Hund's rule and Pauli's principle to write the electron configuration for the selected elements. Learners use the **memorandum** to mark their own work and to make corrections for **formative assessment**.

Practical work:

Give the colours exhibited by some metal cations and metals.

The teacher and the learners check whether all the apparatus needed for this experiment are in order by reading out the apparatus from the worksheet. Learners must confirm by checking the apparatus and make a tick on the list next to the name of apparatus.

Learning and assessment

- Learners discuss and complete the background knowledge as a baseline assessment. Learners may refer to their textbooks when completing this section. The teacher walks around and observes as learners discuss and gives assistance as formative assessment.

- Learners conduct the experiment by executing the action, and then observe the colour of the flame each metal ion and metal produces. They record their observations on the space provided in their worksheets.

Assessment

- The teacher simply **observes and listens** to learners' discussions while using **formative assessment** when learners are kindly assisted in executing some actions or understanding of some concepts. The teacher may choose to use an observation sheet as an assessment tool to be able to identify those who have some problems that may need special attention.
- **Formal assessment** takes place when learners complete the self-evaluation form at the end of the experiment.
- Learners **mark their own answers** to the experiment while the teacher leads the marking by sharing the answers from a written memorandum, which is written on the chalkboard. It is necessary for learners to see the answers and to be given the opportunity to defend their responses and make the necessary corrections as part of the **formative assessment**. Worksheets are collected by the teacher so that he/she may complete the facilitator evaluation and also record the marks for the groups.

Lesson 17

Lesson outcomes are:

- Orally explain what the Periodic Table is and give its uses.
- Explain how elements are arranged in the Periodic Table.
- Define the period number and the group number of an element in the PT.
- Relate the position of an element in the Periodic Table to its electronic structure and vice versa.
- Explain the periodicity of elements (Li to Ar) by looking at the density, melting point, boiling point, and atomic radius of an element.
- Explain the periodicity of elements (Li to Ar) by looking at formulae of halides and oxides.

Teaching and learning activities

- The teacher moves around the classroom while asking learners oral questions related to the periodic table.
- The teacher moves around the classroom while asking learners to explain what they understand of the following concepts: density, melting point, boiling point, and atomic radius.

Assessment

- The teacher uses **baseline assessment** in order to establish what learners know about the Periodic Table.
- **Formative assessment** takes place when the teacher responds to learners' questions during the presentation.
- The teacher continues to use **baseline assessment** in order to establish what learners know about the density, melting point, boiling point, and atomic radius.
- This enables the teacher to **assess the situation** and decide on the basis of learners' knowledge and which teaching strategy to use.
- If learners' prior knowledge about the Periodic Table and the concepts density, melting point, boiling point, and atomic radius is wrong, the teacher has to revive the conceptual understanding.
- If the responses are positive, the formal teaching and learning need to take place.

Teaching activities

- With the Periodic Table presented to the class visually, the teacher explains to learners what the periodic table is and how elements are arranged in the Periodic Table.
- The teacher uses electron configuration to explain the arrangement of elements in each group.
- Special names of certain groups are written on the chalkboard and the teacher explains the relation between groups and valence structure.
- The teacher also explains how the period number relates to the principle quantum number or energy level of an element.
- The teacher explains the relationship between the concepts density, melting point, boiling point, and atomic radius and the periodicity of the elements across the period two of the Periodic Table.
- The teacher writes on the chalkboard the periodicity with regard to density, melting point, boiling point, and atomic radius across the period and down the group.
- The teacher explains the periodicity of elements Li to Ar by looking at the formulae of halides and oxides. A few examples of halides and oxides are illustrated by the teacher on the chalkboard.
- An exercise is given.

Learning activities

- Learners respond to the teacher's questions with regard to the Periodic Table.
- Learners listen attentively to the teacher's explanation of the Periodic Table and how elements are arranged. Learners are given the opportunity to ask questions where they do not understand.
- They write down the special names of certain groups and their relation with the valence structure.
- The relationship between the quantum number (energy levels) and the period number are discussed and notes are taken.
- They discuss and complete the exercise given by the teacher in their exercise books.
- Learners listen attentively and note important facts related to the trend brought about by the periodicity and density, melting point, boiling point, and atomic radius across the period and down the group.
- Learners write down the examples as written on the chalkboard while attentively listening to the teachers' explanation.

Assessment

- The teacher **moves around and observes as** learners write down the examples to ensure that the correct information is written.
- When learners work on the questions in pairs, the teacher moves around and gives guidance and assistance where needed. This enables the teacher to establish which learners do not fully understand the periodicity of elements with regards to density, melting point, boiling point, and atomic radius.
- Learners' attempts are discussed as part of **formative assessment** process before the correct answers are written on the chalkboard. **Each learner assesses his/her own work**. This is regarded as **formative assessment** because each individual learner can see what he/she needs to do to improve.

Library activities 1

- The teacher requests learners to **study** pages 160 – 163 (Kelder, 2008a) of their textbook (see Appendix Y).

Lesson 18

Lesson outcomes are:

- Define and explain the atomic radius, ionization energy, electron affinity, and electron negativity.
- Compare the electron affinity and electron negativity of atoms between groups and periods.
- Explain the periodicity of elements (Li to Ar) by looking at ionization energy of an element.
- Relate the electronic arrangement to the chemical properties of group 1, 2, 7 and 8 elements.
- Describe differences in reactivity of group 1, 2, 7 and 8 elements.
- Predict chemical properties of unfamiliar elements in group 1, 2, 7, and 8 elements.
- Indicate where metals, non-metals and transition elements each can be found on the Periodic Table.

Learning and assessment

Before the teacher can use the electron configuration to explain the reactivity of group 1, 2, 7 and 8 elements, he/she should ask learners to define ionization energy, electron negativity and electron affinity of the elements of a given group.

Assessment

- The teacher uses **baseline assessment** in order to establish what learners know about the ionization energy, electron negativity and electron affinity of elements of a group.
- This enables the teacher to assess the situation and decide on the basis of learners' knowledge, which teaching strategy to use.
- If learners' prior knowledge about the concepts ionization energy, electron negativity and electron affinity is wrong, the teacher has to revive the conceptual understanding.
- If the responses are positive, the formal teaching and learning need to take place.

Teaching activities

- The teacher defines and explains the concepts atomic radius, ionization energy, electron affinity, and electron negativity. He/she continually assesses whether every learner is following and ensures that everybody understands before the definitions are written on the chalkboard for learners to copy in their notebooks.
- The teacher explains the ionization energy of the second period elements looking at the periodicity of such elements. He/she continually checks whether the learners are following and ensures that everybody understands, before each learner is expected to do the similar exercise with the third period elements.
- The teacher relates elements of group 1 electronic arrangement to its chemical properties and learners are given the opportunity to discover the relationship in groups 2, 7 and 8 elements.
- The teacher uses electron configuration to explain reactivity of elements of group 1, 2, 7, and 8. The learners understanding of the concepts ionization energy, electron negativity and electron affinity will be used to achieve effective teaching.
- Based on learners understanding of elements reactivity, the teacher will give learners a chance to predict the reactivity of certain elements.

- With the Periodic Table placed in front of the learners, the teacher guides learners to indicate the position of metals, non-metals and transition elements.

Learning activities

- The learners listen attentively as the teacher explains and defines the concepts atomic radius, ionization energy, electron affinity, and electron negativity and write down the definitions on their notebooks.
- Learners discuss the ionization energy of the third period elements looking at the periodicity of the elements and draw conclusion thereafter.
- Learners continue to discuss the relationship of electronic arrangement to the chemical properties of group 2 elements.
- Learners listen carefully listen to the teacher's explanation of reactivity of elements of group 1, 2, 7, and 8 and note important conclusions.
- The learners discuss their opinion and give their attempts.
- The learners respond to the teacher's questions based on the Periodic Table.

Assessment

- The teacher walks around and **observes** the note taking and summarising.
- The teacher and the learners listen critically to the other learners' responses to the ionization energy of period three elements and learners' prediction of elements' reactivity. Once again the teacher helps with the correct scientific relationship. In this way, **informal peer-assessment** and teacher assessment are used in a **formative** way, while feedback is given to improve learning.
- When learners work in pairs on the electronic arrangement of group 2 elements, the teacher walks around and gives guidance and assistance where needed. Learners continue to work in pairs to identify the position of metals, non-metals, and transition elements on the Periodic Table. The teacher continues to walk around, observe and give guidance and assistance where needed. He/she will then be able to see which learners do not understand the electronic arrangement of group 1 elements and may lead to individual attention to some learners.

Lesson 19

Lesson outcomes are:

- Explain how chemical bonding takes place.
- Name and explain the types of chemical bonding.
- Explain the significance of the valence electron.
- Explain how metallic bonding determines the properties of metals.

Teaching and learning activities:

- The teacher asks the class what they know about atoms, molecules, mixtures and compounds. He/she further asks them to explain how molecules, mixtures and compounds are formed. The teacher may direct the questions to any learner even if the learner has not raised the hand.

Assessment

- **Baseline assessment** is used when the teacher listens to learners' oral responses and establishes what they about the concepts.
- The teacher assesses the situation and decides which action to take: if learners' knowledge about the concepts is not in line with the scientific explanations, it will be necessary to go back to atoms, molecules, mixtures and compounds. If this is the case, formal teaching and learning has to take place.

Teaching activities:

- The teacher uses the Bohr model diagrams to explain to learners what bonding is and how it takes place.
- Chemical bonding is explained by the teacher with reference to the Periodic Table and valence electrons.
- The significance of valence electron in chemical bonding is explained in depth.
- The teacher asks learners to orally give the properties of metals and the teacher explains how metallic bonding determines such properties.

Learning activities

- Learners discuss and orally respond to the questions asked by the teacher in relation to bonding and chemical bonding.
- Learners listen attentively to the teacher's explanation of the concepts bonding, chemical bonding and metallic, and take notes.

Assessment

- **Formative assessment** takes place when learners respond to questions asked by the teacher in connection to bonding and chemical bonding.
- **Informal formative assessment** takes place when other peers and the teacher critically listen to other learners' responses and offer guidance or correction where necessary.
- The teacher moves around and takes a look at the learners' notes to ensure that correct interpretation of facts is correct.

Homework activity 4

- Learners are requested to do activity 12 question 2 on page 167 of their prescribed textbook (Keldr, 2008a:167) (see Appendix Y) at home and it is assessed during the following lesson.

Lesson 20

Lesson outcomes are:

- To assess own answers.
- Describe the formation of covalent bond.
- Draw the formation of covalent bond of simple covalent molecules.
- Describe using the electron diagram the formation of single bond, double bonds, and triple bonds of simple covalent molecules.
- Write the names of covalent compounds in terms of the elements present.
- Write the formulae of covalent compounds in terms of the elements present and the ratio of their atoms.
- Give the properties of giant covalent compounds.

Assessment

- The teacher asks each of the questions that had to be answered in writing on metals and randomly chooses learners to respond to the questions. Responses are discussed as part of the **formative assessment** process before the correct answers can be written on the chalkboard. All learners are invited to listen attentively to responses and share their views. **Each learner assesses his/her work**.

Teaching activities

- The teacher explains what covalent bonding is, and makes use of “two learners wanting the same book” to demonstrate covalent bond.
- He/she uses the Bohr model diagram and Lewis dot diagram to explain the formation of a covalent bond of simple covalent molecule (e.g. H_2, O_2, H_2O, and N_2).
- He/she requests learners to draw the Bohr model diagram for NH_3 and HCl molecules.
- The teacher further uses the electron diagram to describe the formation of single bond, double bond, and triple bond.
- The teacher shows learners how to name covalent compounds in terms of the elements present in that compound.
- He/she explains how to write the formulae of covalent compound in terms of the elements present and the ratio of their atoms using the valency.
- The properties of giant covalent structures are discussed and examples are given.

Learning activities

- Learners observe as the two learners demonstrate covalent bond using a book.
- Learners listen attentively as the teacher explains the formation of covalent bond with the aid of the Bohr diagrams and Lewis structures. They note down relevant information.
- The learners draw the Bohr model diagrams for NH_3 and HCl in their exercise books.
- The learners copy into their notebooks the electron diagrams written by the teacher on the chalkboard to describe the formation of single, double and triple bond of simple compounds.
- Learners orally name some of the covalent compounds written on the chalkboard.
- Learners copy from the chalkboard the formulae of some covalent compounds.
- Learners share their views with regard to the properties of giant covalent structures.

Assessment

- The teacher moves around and attentively observes and listens to learners' discussions about the two learners wanting a book demonstration.
- The teacher checks learners' notes for errors and corrections are hinted where necessary.
- **Self-assessment** takes place when learners mark their work. The **memorandum** is written on the chalkboard. **Formative assessment** takes place because learners see the correct diagrams and do a short remedial exercise in which they correct their own errors.
- **Informal formative assessment** takes place when other peers and the teacher critically listen to other learners' responses and offer guidance or correction where necessary.
- The teacher moves around and takes a look at the learners' notes to ensure that correct interpretation of facts is correct.
- **Informal formative assessment** takes place when **peers and the teacher** critically listen to others' responses about the properties of giant covalent structures. **Formative assessment** takes place when the teacher correct learners' responses and scientifically correct properties are written on the chalkboard.

Library activity 2

Learners are requested to study pages 176 – 180 (Naming compounds) and pages 199-200 (Writing chemical formulae) of their textbook (Kelder, 2008a) (see Appendix Y).

Lesson 21

Lesson outcomes are:

- Naming compounds and writing formulae of compounds.
- Describe using electron diagrams, the formation of ions.
- Describe using electron diagrams, the formation of ionic bonds.
- Draw electron diagram of cations and anions.
- Predict the ions formed by atoms of metals and non-metals using information in the Periodic Table.
- Name ionic compounds based on the component ions.

Assessment

- Learners are asked to write the names of the following compounds: CaO, PbO_2, $Ca(HO)_2$, H_2SO_4, AgBr, and the formulae for: potassium sulphate, Ammonium sulphate, sodium oxide, carbon dioxide, and sodium nitrate.

- **Peer-assessment** is used to mark the class work. Answers are written on the chalkboard. The teacher and learners decide what the minimum score should be to get a stamp/sticker. The summative assessment results are not recorded and reported, but used in a **formative** way because learners see the correct answer and remedial exercise in which they correct their own mistakes.

Teaching activities

- Learners' conceptual understanding of the concepts valence electron, valency electron, electron affinity, and ionization energy is orally tested.
- Using the electron diagrams, the teacher describes the formation of ions.
- The teacher continues to use electron diagrams to explain how ionic bond is formed.
- The teacher draws the cations and anions diagrams and explains how the Periodic Table can be used to determine the charge of an atom.
- He/she asks learners to predict and name ions formed by atoms of metal and non-metals using the Periodic Table. The exercise is peer-assessed.

Learning and assessment

- The teacher requests learners to study the tables listing anions and the polyatomic ions in order to be able to name ionic compounds based on the component ion.

Learning activities

- Learners orally explain or define the following concepts: valence electron, valency electron, electron affinity, and ionization energy.
- They listen attentively and ask questions as the teacher describes the formation of ions. They take notes.
- Their attention is drawn to the chalkboard as the teacher uses the diagram to explain how the ionic bond is formed. They take note.

- Learners take note of what the teacher is explaining with regards to the use of Periodic Table to determine the ion of an atom and predict and name ions formed by atoms of metals and non-metals elements.

Assessment

- **The baseline assessment** is used to establish learners' prior-knowledge with regard to the concepts valence electron, valency electron, electron affinity, and ionization energy.
- The teacher moves around and checks the learners' notes for errors and correct where necessary.
- **Formative assessment** takes place when the teacher responds to learners' questions or when clarifies any concepts.
- **Informal formative assessment** takes place when peers and the teacher critically looks at others' responses about the names and ions predicted using the Periodic Table. **Formative assessment** takes place when the teacher corrects learners' responses and scientifically correct properties are written on the chalkboard.

Homework activity

Learners are asked to give the Lewis structure to illustrate the formation of ionic bonds and to name the substances formed.

1.1 sodium and oxygen

1.2 potassium and chlorine

1.3 aluminium and fluorine

The work will be peer-assessed during the following lesson.

Lesson 22

Lesson outcomes are:

- Formation of ionic bond using Lewis structure and naming the substances formed.
- Describe the structure of an ionic crystal.
- Describe the simple model of metallic bonding.
- Discuss the cation and anion tables.
- Write the names of chemical compounds correctly.
- Give the relative molecular mass for covalent molecules.
- Write the relative formula mass for ionic compounds.

Assessment

Learners are asked to write the Lewis structure to illustrate the formation of ionic bonds and names of the substances formed from: sodium and oxygen, potassium and chlorine, and aluminium and fluorine.

Peer-assessment is used to mark the class work. Answers are written on the chalkboard. The teacher and learners decide what the minimum score should be to get a stamp/sticker. The **summative assessment** results are not recorded and reported, but **used in a formative way** because learners see the correct answer and remedial exercise in which they correct their own mistakes.

Teaching activities

- The teacher describes the structure of ionic crystal using NaCl structure as an example. The inter-molecular and extra-molecular forces are also explained.
- The teacher makes use of the ionic crystal lattice model made from polystyrene balls and skewer sticks. He/she invites learners to design their ionic crystal models using bottle tops.

Learning activities

- Learners note the important facts and ask questions where they do not understand.
- Discuss in pairs the cation and anion tables as they appear in their textbooks.

Learning and assessment

- Learners write names of chemical compounds of their choice and ask his/her peer to assess his/her work. The teacher moves around, listens and gives advices where necessary.
- Learners do the same with the relative molecular and formular masses in the presence of their teacher, who continues to offer assistance, were it is needed.

Homework activity

Learners must revise the theme matter and materials in preparation of the summative assessment test that will be peer-assessed during the following lesson.

Lesson 23

Lesson outcomes are:

- Learners must demonstrate understanding of the theme matter and materials.
- Reflect on their learning over the last three weeks by ticking off assessment standards that have been attained and by making an entry into their portfolios focusing on their personal development and instructional improvement.

Teaching and learning activities

- A 30 mark test is written on matter and materials.
- Each learner assesses a partner's test, pays special attention to feedback and does remedial work on his/her own answers.
- The teacher and learners reflect on the attainment of learning Outcomes and Assessment Standards and use a thick coloured pen to tick off the assessment standards that have been incorporated in the learning cycle on the checklist against the wall. Learners get the opportunity to see which assessment standards they have attained and should experience a sense of achievement and success.
- Each learner reflects on his/her own learning and progress by completing the form on which he/she has stated personal learning objectives at the beginning of the learning cycle (see Appendix M).
- The teacher shares the learning objectives of the following learning cycle with the learners.

Assessment

- **Peer assessment** is used to mark the test. Answers are written on the chalkboard. The teacher and learners decide what the minimum score should be to get the sticker/stamp. The **summative assessment** results are not recorded and reported but used in a formative way because learners see the correct answers and do a short remedial exercise in which they correct their own errors.
- The teacher and the learners reflect on the attainment of Learning Outcomes and Assessment Standards.
- Each learner gets the opportunity to reflect on his/her own learning and progress and is invited to share the information with the teacher who review his/her teaching.

Homework activity

- The theme of the next cycle is discussed with the learners and they are given the task to do in preparation for the first lesson on the next cycle. In this case the next theme is waves, sound and light and learners are asked to study the theme.

10.6 Other things to consider when planning assessment tasks

It is evident from the above that in order to develop an effective assessment task, the teacher must ensure that the assessment task is aligned to the LOs and the ASs. The task should focus only on Physical Sciences, and if it integrates with other subjects, learners should be informed in advance. The task should be intellectually challenging, yet achievable by all learners and should be based on learners' developmental stages. The tasks should be structured in such a way that it enables the teacher to assess different knowledge and skills. The language used should be clear and understandable to all learners. If the assignment is given in writing, cultural and linguistic background should be considered. The tasks should be assessed on time and feedback should be given immediately after assessment. Follow-ups should be done were necessary.

The following questions can be used by teachers to guide formulation of assessment task questions:

- What critical thinking process do you want to nurture?
- What learning outcomes do you want to achieve?
- What types of answers will you accept?
- What skills do you wish to develop?
- What attitudes and values do you wish to emphasise?

Moreover, the teacher should ensure that the assessment tasks should, amongst others:

- be understood by the learners;
- be clearly focused;
- be integrated with teaching and learning;
- be based on pre-set criteria of the assessment standards;
- allow for expanded opportunities for learners;
- be learner paced and fair;
- be flexible;
- use variety of instruments;

- use variety of methods;
- serve the purpose of assessment;
- be appropriately scheduled in the learning cycle.

If well-structured, effective assessment can serve the purpose of enhancing effective teaching and learning as well as providing reliable information for promotion of learners.

10.7 Conclusion

The model presented in this chapter demonstrates the practical implementation of OBA of Physical Sciences in the FET Band as depicted in the NCS, having taken into account the CAPS document. In essence, the model is designed to facilitate OBA for the following reasons:

- It demonstrates the interaction between teaching, learning and assessment in Physical Sciences;
- It shows the type of learning activities that can be aligned with the Physical Sciences Learning Outcomes;
- It demonstrates how LOs and ASs can be broken into lesson outcomes;
- It aligns assessable tasks with LOs and ASs and makes it clear how learner performance should continuously be assessed for learning;
- It demonstrates how different types and methods of assessment should be used in order to improve learner performance;
- It demonstrates the connection between different types of assessment and the role played by each type;
- It shows how ASs can be used as criteria for assessment;
- It shows how to plan and effectively implement practical work ;
- It shows the role played by teachers and learners during practical work;
- It demonstrates how to involve learners in assessment so that they can be guided towards taking responsibility for their own learning;
- It demonstrates how teaching and assessment activities can be designed to develop different skills, attitudes and values;
- It demonstrates how teaching and assessment activities can be planned in such a way that they provide learners with the opportunity to acquire and develop practical, scientific and problem solving skills;
- It demonstrates how teaching and assessment activities can be planned in such a way that they provide learners with the opportunity construct and apply scientific knowledge;

- It shows that teaching and assessment activities can be planned in such a way that they provide learners with the opportunity to identify and critically evaluate the contested nature of science and its relationships to technology, society and the environment;
- It demonstrates how teachers can design and implement effective learning, teaching and assessment strategies that will engage learners effectively;
- It demonstrates how teachers can design assessment activities that are based on the principles of high quality assessment (reliability, validity and authenticity);
- It demonstrates how teachers can design and implement assessment activities for practical work;
- It demonstrates how teachers can use different teaching and assessment strategies to promote scientific inquiry skills;
- It shows how parents can be involved in the learning and assessment of their children.

The implementation of this model will enable teachers to experience the benefits of teaching in a learner-centred way by involving learners in what is happening in the classroom and laboratory: sharing outcomes with them so that they know where they are heading, sharing assessment criteria with them so that they know what is expected of them and involving them in peer- and self-assessment activities.

In Chapter 11, the study will be summarized and further recommendations will be made to facilitate the effective implementation of OBA of Physical Sciences in the FET Band.

CHAPTER 11

Summary and recommendations

11.1 Introduction

This chapter provides a brief summary of the study. On the basis of the findings emanating from the empirical part of the study and the conclusions that were drawn, recommendations will be made to facilitate the effective implementation of OBA of Physical Sciences in the FET Band. Some recommendations for further research will also be proposed, and the chapter will end with some concluding thoughts.

11.2 Summary of the study

In Chapter 1 the reader was oriented with regard to the study. The research problem, aim and objectives were stated and the research design and methodology that were implemented in the empirical part of the study were briefly discussed. Information was given about the ethical considerations that guided the research and a brief exposition of the different chapters in the thesis was provided.

Assessment and related concepts were introduced in Chapter 2. The origin of the concept assessment was discussed and different views on assessment were highlighted. School based assessment strategies such as measurement, tests, examinations, experimentation and practical work were discussed and the role that assessment plays in teaching and learning was explored. Negative applications of assessment were identified and discussed, and the chapter concluded with an exposition of the evolution of Outcomes-Based Assessment.

Chapter 3 addressed learning in sciences and how effective learning can be achieved. Prominent learning theories that influence teachers' teaching strategies in Physical Sciences were explained and discussed and on the basis of this the historical development of the constructivist approach to science teaching was explained. Finally, the relationship between constructivism and Outcomes-Based Education (OBE) was discussed.

In Chapter 4 the introduction of Curriculum 2005 to the South African education landscape was addressed. The origin and historical development of the Outcomes-Based approach were explored and OBE was defined. The educational implications of the OBE approach were discussed in terms of its basic premises, namely that all learners can learn and succeed, but not at the same time or in the same way; Successful learning promotes even more successful learning and schools (and teachers) control the conditions that determine whether or not learners are successful at school learning. The chapter also explored the principles of OBE, namely: clarity of focus, design down, high expectations, and expanded opportunities, and related them to constructivism and the National Curriculum Statement.

Chapter 5 addressed the role of Outcomes-Based Assessment in sciences and further suggested certain options to be followed when developing effective assessment tasks, with an emphasis on principles of high quality assessment (i.e. reliability, validity and authenticity). A comparison was made between authentic and traditional assessment. The chapter concluded by identifying factors that are important for the standard of OBA. Five factors were identified and explained, namely: consistency, achievement and opportunity to learn, technical quality of data, and inferences made from assessment about learner achievement and opportunity.

In Chapter 6 the importance of diversifying assessment modes and the need for improving Physical Sciences teachers' expertise in designing OBA tasks were explained. The characteristics of effective OBA were highlighted and extrapolated. Different OBA approaches and tools were discussed and the chapter concluded with an explanation of how assessment tasks should be moderated and a consideration of its importance.

Chapter 7 described the relationship between outcomes and the taxonomies of educational objectives with reference to the influence of Bloom's Taxonomy on the National Curriculum Statement. In addition, the chapter discussed the Anderson-Krathwohl taxonomy and its application potential for assessment. The reader was introduced to the SOLO-taxonomy and how it can be applied to produce LOs of sufficient complexity and to describe a learner's level of understanding of particular learning content or process. The outcomes in NCS were explained and the chapter concluded with an overview of OBA of Physical Sciences, and how Physical Sciences should be assessed in the FET Band.

In Chapter 8 the research design and methodology were discussed. The research aim and objectives were stated and the choice of research design was motivated. The quantitative and qualitative methodologies that were implemented in the investigation were described.

In the first part of Chapter 9 the quantitative results emanating from the survey were presented in three sections. The first two sections dealt with the participants' biographical details and their responses to the structured items in Section B of the questionnaire, and the results were presented in the form of frequency tables. The following section dealt with the validity and reliability of Sub-sections B4 and B5 of the questionnaire and for this purpose factor analyses were done and Cronbach's Alpha coefficients were calculated. The relationship between certain biographical and situational variables and factors contributing to the assessment of Physical Sciences in the FET Band were investigated and for this purpose ANOVA's and t–tests were conducted. The chapter offered a summary of the results emanating from the quantitative and qualitative parts of the research, followed by a discussion of the results. In the second part of Chapter 9 findings emanating from the quantitative and qualitative research were presented and discussed. The chapter ended with the conclusions drawn from the quantitative and qualitative findings.

In Chapter 10 a model for the Outcomes-Based Assessment of Physical Sciences in the FET Band was proposed.

11.3 Recommendations

Recommendations to enhance the OBA of Physical Sciences in the FET Band are based on the conclusions that were drawn with regard to the primary and secondary research questions (see paragraph 9.16).

11.3.1 Recommendations for the Department of Basic Education

In order to alleviate teachers' lack of practical implementation skills, the following recommendations are made:

a) <u>Recommendations with regard to teacher training</u>:

- Teacher training in OBA should be conducted by competent and experienced trainers;
- Training should be subject specific;
- Enough time should be spent on training and it should provided on an ongoing basis;
- All subject advisors should undergo continuous subject specific training; and
- Emphasis in training should be placed on the practical implementation of OBA.

Motivation

The finding of the empirical study indicates that some of the participants received inadequate training in OBA of Physical Sciences, some of them complained that the training was presented by incompetent trainers and lacked practical application value (paragraph 9.16.2).

These recommendations are also supported by the Ministerial Task Team for the Review of the Implementation of the NCS (DBE, 2009: 7) when it was recommended that: *"The training of teachers to support curriculum implementation should be subject specific and targeted only where needed; and all support staff, including school management, subject advisors and district officers, should also undergo training on the Curriculum and Assessment Policy".*

(b) Recommendations with regard to curriculum policy and guideline documents:

- Curriculum policy and guideline documents should be simplified;
- Terminology and language of the curriculum should also be simplified;
- Curriculum overload should be addressed;
- Content should be relevant to real-life situations and should be practical (doable); and
- There should be coherence of subject content between successive grades.

Motivation

The outcomes of the empirical study indicate that some of the participants found the NCS document complicated and confusing and felt that it does not contain clear guidelines. They further stated that the curriculum is too full and that its contents are irrelevant to real-life situations (paragraph 9.16.2).

The report of the Ministerial Task Team (DBE, 2009:7) also supported the above recommendations when it stated that: *"one Curriculum and Assessment Policy document for every learning area and subject (by phase) that will be the definitive support for all teachers and help address the complexities and confusion created by curriculum and assessment policy vagueness and lack of specification, document proliferation and misinterpretation should be developed*. This recommendation resulted in the development of the different subject specific Curriculum and Assessment Policy Statements (CAPS).

(c) Recommendations with regard to assessment activities:

- Teachers should be specifically trained on how to design and develop high quality OBA activities;
- Teachers should be trained on how to meaningfully implement CASS in the assessment of Physical Sciences in the FET Band;

- Teachers should be trained on how to conduct high quality formal and informal assessment tasks;
- Challenges with regards to examinations should be addressed during the teachers' workshops and training sessions;
- Workshops should be held at the end of the year to assist teachers in drawing up assessment schedules for the next year;
- OBA help desks should be established on provincial, regional and school district levels to support teachers when need for assistance arises.

Motivation

Based on the finding, most experienced participants in teaching the subject were generally cognisant of the principles of high quality assessment than the less experienced once. The middle aged participants were on average more competent to effectively implement the OBA of Physical Sciences in the FET Band, although their assessment activities were on average more teacher-centred than that of younger participants. They seem to lack in designing and implementing effective assessment activities that will benefit both the teacher and the learner. It also emerged that younger participants were on average more inclined towards informal assessment tasks than their older counterparts. They seem to be more concerned about providing additional support to learners than the older participants (paragraph 9.16.2).

The above recommendations are also supported in the report of the Ministerial Task Team (DBE, 2009:8) where it was said that *"the department should clarify Subject Advisor roles nationally and specify the exact nature of in-classroom and school support they should provide to teachers. Subject Advisors roles differ from province to province and district to district; and yet this role is the main intermediary between the curriculum policy and classroom interpretation"*.

(d) Recommendations with regard to practical work:

- Teachers should be adequately trained to design practical work activities and to conduct practical work using various types of laboratory apparatus;
- Adequate departmental support should be given especially on using practical work methods when assessing learners in Physical Sciences;
- All schools be supplied with the necessary science equipment;
- Media resources should be made available to all schools;
- Physical Sciences classrooms should accommodate a manageable number learners; and

- More teaching time should be allocated to Physical Sciences so that more practical work can be done.

Motivation

Based on the finding, some participants do not instruct learners to conduct experiments and practical work due to lack or absence of resources; they claim to be inadequately trained to conduct experiments or did not receive any training in practical work at all. Some indicated that the workload does not allow time for experiments and practical work. Some of the participants do not use effective scientific strategies to teach scientific inquiry skills during practical work due to: A lack of resources; overcrowded classes; the overloaded curriculum; limited availability of teaching time and lack of media resources (paragraph 9.16.2).

Furthermore, participants with teaching degrees found that the lack of resources and departmental support prohibits them from using experimentation and practical work to assess their learner in Physical Sciences in the FET Band schools. They seem to lack practical implementation skills of practical work of Physical Sciences more so than the highly experienced participants (paragraph, 9.16.2).

According to CAPS, the aim of Physical Sciences in South African Education is to promote knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and technological knowledge; understanding of the nature of science and its relationship to technology, society and the environment (DBE, 2011:8). If schools are not fully resourced, and teachers given the necessary training they deserve, this aim cannot be achieved.

Physical Sciences is a subject that focuses on investigating physical and chemical phenomena through scientific inquiry (DoE, 2003b:9). For that reason, learners' participation in practical work will enable learners to apply scientific principles, stimulate their curiosity, deepen their interest in the physical world they live in, develop useful skills and attitudes that will prepare them for various situations in life. Learners who are not involved in practical work are denied their right to quality education.

(e) Recommendations with regard to the provision of Learning and Teaching Support Materials (LTSMs):

- Appropriate and sufficient learning and teaching support materials should be made available to all schools (e.g. examples of work schedules, learning programmes, lesson plans, practical work assessment tools and textbooks); and
- Delivery of all LTSMs should be effective and on time;

Motivation

Findings indicate that there were no support materials such as assessment tools available at the training sessions. The participants consequently felt that: *"Programme of Assessment must have pre-designed lesson practical investigations i.e. per core knowledge area." "..... Lesson plans be "readymade" and correlate with the work schedule though we are told to plan according to the environment yet examiners do not consider the environment factor ……." ".....We prefer one prescribed textbook especially for the learners." "…….We must have a stable policy that is not revised timeously (meaning over and over)." "……The recording sheets must be revised to cater for tasks suggested above.* (Paragraph 9.14.9.3.8)

The above recommendations were supported by Ministerial Task Team (DBE, 2009:9) and they recommended that *"The quality assurance and catalogue development for textbooks and other (Learner Teacher Support Materials) LTSM need to be centralised at the National level; the useful role and benefits of textbooks needs to be communicated at the highest level, and each learner from Grade 4 to Grade 12 should have a textbook for each learning area or subject"*. The report emphasized that from 2010 onwards the implementation of this recommendation should receive high priority.

Unfortunately, it seems as if this recommendation was not prioritized equally in all provinces in South Africa. For example, the Minister of Basic Education and MEC for Education in the Limpopo Province were taken to the Gauteng North High court by a Section 27 Non-Governmental Organisation (NGO) due to failure by the Department of Basic Education and the Department of Education Limpopo to provide textbooks to some of the schools in Limpopo Province. The two parties did jointly agree on a delivery date of 31st May to 15th June 2012 (DBE, 2012:1). However, this agreement was not honoured and many schools and learners were still without books after delivery date had passed.

When he was awarded the Honorary Professorship by the Perking University, Beijing, President Jacob Zuma indicated that "no country can succeed if it does not invest in its people through education" (South African Gov, 2012). For that reason, it is high time that the Government put the money where its mouth is by ensuring that all schools in the country are equipped with necessary infrastructure and LTSMs.

11.3.2 Recommendations for the Provincial education department

In order to alleviate some of the teachers' lack of practical implementation skills, the following recommendations are made:

(a) <u>Recommendations with regard to teacher training in OBA</u>

The provincial department of education must:

- ensure that teacher training in OBA is conducted by competent trainers;
- ensure that all subject advisors' possess sound subject content knowledge;
- ensure that all subject advisors have adequate experience in teaching Physical Sciences;
- provide regular and continuous training to teachers and the emphasis should fall on aspects related to the teaching and practical implementation of OBA in Physical Sciences;
- ensure that all support staff, including district officers and school management teams, undergo regular OBA training; and
- collaborate with other provinces on a regular basis in order to exchange ideas about the curriculum and its implementation, with specific reference to OBA.

Motivation

The provincial department of education is the eye of the Department of Basic Education at provincial level. Therefore the provincial department of Education must at all times ensure that the quality of teaching is up to standard because if the quality of teaching is below standard the quality of education in the province will be compromised, leaving the learners in the province with a bleak future.

The participants indicated their concerns relating to the quality of the training they received. They experienced the training as inadequate and felt that it would not enable them to successfully implement the curriculum. Participants voiced their frustration by making comments such as: *"If one is not properly trained, there is no way one can implement or impart information to others or put to practice what one has learned"* This participant's statement implies that despite the amount of subject knowledge one has, if the curriculum is not clearly understood by the teacher, it will be very difficult to impart information to learners (paragraph 9.14.2.1).

(b) Recommendations with regard to curriculum policy and guideline documents

The provincial department of education must:

- ensure through regular training opportunities that teachers understand the content of the curriculum policy and guideline documents;
- simplify the policy documents and streamline the curriculum content for teachers;
- ensure coherence of subject content between the successive grades; and
- ensure that every teacher is in possession of relevant curriculum policy and guideline documents.

Motivation

It is the responsibility of the provincial department of education to ensure that teachers are properly trained to implement the curriculum. Therefore the department should continuously provide the necessary training and support to regions, districts, and schools.

It transpired from the participants' responses that the training that they have received was not adequate enough to enable them to implement the OBA of Physical Sciences effectively because they were trained by incompetent trainers who could not respond to their questions. One participant aired his/her frustration by stating that "*I still have a lot of problems in understanding the underlying principles of AOB* (meaning OBA)*. It appears the actual AOB we talk about is not the one that is in place at the moment".* The cause of this confusion may be brought about by the fact that *"training was done by our teacher colleques* (referring to colleagues) *whom in my opinion I think they find it difficult as well"(paragraph 9.14.1.2).*

(c) Recommendations with regard to assessment activities

The provincial department of education must:

- ensure that teachers are well trained to design effective OBA activities;
- ensure that teachers understand the role of formal and informal assessment activities in OBA;
- provide relevant and adequate departmental support on a regular basis;

- establish regional and district OBA help desks.

Motivation

The empirical study indicates that the short duration of the training did not allow for practical application of OBA. Moreover, as training was conducted by individuals who seemed to be incompetent with OBA of Physical Sciences themselves (paragraph 9.7.1.2), there was no way practical application was imminent. One participant indicated that *"the training was done theoretically"* and went further to state that "*demonstrations should have been done in class with the learners to see if OBE is possible."* Indeed *"it was a crash course and not a detailed developmental workshop as we expected, since this was a completely new concept".* The Department of Education did not make adequate preparations to train teachers (paragraph 9.14.1.3).

In the National Curriculum Statement, assessment is regarded as an integral part of teaching and learning. For that reason, assessment should be part of every lesson and teachers should effectively plan assessment activities to complement learning activities (DBE, 2011:119). If teachers fail to assess effectively, then the standard of education in the country will be compromised because teaching, learning and assessment are inseparable.

(d) Recommendations with regard to practical work

The provincial department of education must:

- train Physical sciences teachers to design practical work activities;
- train Physical Sciences teachers to confidently use various experimental apparatus;

Motivation

The aim of the Physical Sciences curriculum is to produce learners who are, amongst other things, capable to collect, analyse, organise, and critically evaluate information and use science and technology effectively and critically, showing responsibility towards the environment and the health of others (DBE, 2011:5). These skills can only be promoted through practical work.

Empirical study indicates that some participants complained about the lack of resources to do practical work. Where there are resources they are insufficient or participants had to rely on external sources for conducting practical work. In this regard some of the participants commented that *“there are no resources which are sufficient for learners to carry out experiments and even a demonstration by the educators”.* The participants went on to indicate that *“the equipment in the lab is not working or the chemicals are long expired”.* Other participants commented that the “*school does not have a laboratory”,* or that *“there are no apparatus, no laboratory, and no DVD”.* One participant commented that the school solely relies on external sources for conducting experiments*: “there is a mobile laboratory which visit the school once a term”*. This means that if the particular company stops the project, no practical work will be conducted in this and other schools (paragraph 9.16.2).

(e) Recommendation with regard to Learner Teacher Support Materials and science apparatus

The provincial department of education must:

- ensure that LTSMs are made available to all schools in time;
- ensure that only prescribed materials are ordered by the region;
- appoint reliable and honest suppliers of LTSMs; and
- ensure that delivery of all materials is on time.

Motivation

One of the aims of the South African Curriculum is to equip learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment, and meaningful participation in society as citizens of a free country (DBE, 2011:4). If teachers and learners do not receive the necessary LTSM on time, then self-fulfilment and meaningful participation in society as citizens of a free country remain a pipedream.

For the effective implementation of OBA of Physical Sciences in the FET, some of the participants suggested that the department can enhance it by “*Making the resources available in all schools (where physics is offered by learners)” ..... “more materials to be provided,” ……”More resources can be given to schools. The department can provide everything to the schools.”*(paragraph 9.14.9.3.8)

11.3.3 Recommendations for the teacher training institutions

In order to alleviate Physical Sciences teachers' lack of practical OBA implementation skills, the following recommendations are made for teacher training institutions:

- Collaborate closely with departments of education for the purposes of developing and presenting in-service programmes (short courses) to Physical Sciences teachers in the FET Band;
- Develop and or modify curricula for pre-service teachers so that prospective teachers are professionally equipped in terms of the subject knowledge skills and methodology of teaching Physical Sciences in the FET Band;
- Faculties of Education and departments of Science Education should continuously focus their research on teaching, learning and assessment of Physical Sciences in the FET Band and share their research findings and recommendations with departments of education, teacher trade unions, schools and teachers;
- Liaise closely with schools in the community and provide necessary professional support where necessary;
- Adopt schools and provide professional and motivational support; and
- Avail resources to needy schools.

Motivation

The above recommendations are supported by those of the Ministerial Task Team when it recommend that *"Higher Education Institutions should align their teacher training programmes with national curriculum policies to enable better alignment between the current (largely generic) teacher education programmes and focused training required for successful curriculum implementation"* (DBE, 2009:67).

Higher Education Institutions in South Africa are the custodians of the development of the country. South Africa's National growth and global competitiveness is dependent on continuous scientific improvement and innovation, driven by well-organised, vibrant research and development systems that integrate the research and training capacity of higher institutions with the needs of industry and social reconstruction (Ministry of Education, 2001:4).

11.3.4 Recommendations for schools

In order to alleviate teachers' lack of practical OBA implementation skills, the following recommendations are made for schools:

- Schools must develop a school-based OBA-policy that can guide all aspects of assessment in the school;
- School assessment teams should be established to provide continuous support and guidance for teachers;
- Clusters within circuits, regions and provinces should be formed so that teachers of Physical Sciences can support and assist each other;
- Schools must become part of a district assessment team so that teachers can be kept abreast of the latest curriculum developments;
- Schools should invite specialists to conduct OBA workshops or seminars at the school;
- Schools should encourage and support teachers to attend OBA training programmes and to register for OBA courses offered by universities and other institutions;
- Schools must ensure that all Physical Sciences teachers are properly trained to conduct practical work in Physical Sciences;
- Schools must allocate the necessary resources and apparatus for conducting practical work in Physical Sciences classrooms and ensure that all apparatus are in good working order;
- Schools should allocate more time on the time table for practical work in Physical Sciences;
- Schools must ensure that media resources are available and in good working order;
- Schools must enforce the prescribed teacher-learner ratio at the school to avoid classroom overcrowding;
- Schools should appoint only suitable science teachers.

Motivation

The school is regarded as the most important role-player in planning and implementation at the micro-education level. In order to facilitate the implementation and development of the OBA of Physical Sciences, an assessment plan is necessary. The design, implementation, maintenance and monitoring of this plan is the task of the Subject Assessment Team, which comprises the principal and/or vice-principal, head of department, all teachers teaching Physical Sciences in the schools.

11.3.5 Recommendations for teachers

In order to assess more effectively, teachers should:

- empower themselves with sound knowledge of all official documentation needed for the successful implementation of OBA;
- be part of the school assessment committee and take part in developing school-based OBA policies that will guide all aspects of assessment at the school;
- make sure that an effective teaching, learning and assessment programme for Physical Sciences is available at the beginning of each year;
- take every learner's needs into consideration and teach and assess according to the needs and abilities of each learner (Every learner can succeed, but at different times);
- ensure that critical and developmental outcomes are contextualised within the framework of learning outcomes and assessment standards;
- always share learning outcomes and assessment criteria with the learners before any assessment activity can take place;
- integrate formative assessment into their lessons on a regular basis;
- supply the necessary scaffolding in the execution of learning activities;
- design assessment activities that provide learners with the opportunity to acquire and develop:
    - practical, scientific and problem solving skills;
    - the ability to construct and apply scientific knowledge;
    - the ability to identify and critically evaluate the contested nature of science and its relationships to technology, society and the environment;
- seek information and always try to get first-hand information on developments within their areas of specialisation;
- design assessment activities with the aim to:
    - develop learners' knowledge, skills and values;
    - assess learners' strengths and weaknesses;
    - provide additional support to learners;
    - revisit or revise certain sections of the curriculum;
    - motivate and encourage learners;
- always consider the principles of high quality assessment (reliability, validity and authenticity) when they plan their assessment tasks;
- ensure that their CASS activities:
    - provide them with reliable information of learners' progress;
    - encourage learners to actively take part in learning and assessment;

- enable learners to set their own goals by involving them in self- and group-assessments;
    - provide feedback on the quality of learning and teaching;
    - allow for different assessment strategies;
    - provide for a variety of learner needs through utilization of different assessment strategies;
    - enable them to cover more extensive sections of the curriculum;
    - enable them to assess skills and concepts that are difficult to assess in examinations or tests situations;
- make use of the following strategies to teach learners' scientific inquiry skills during practical work:
    - Demonstrations;
    - Hands-on experiments;
    - Simulations;
    - Multimedia presentations;
- report regularly and timeously to learners and parents on the progress of learners;
- use assessment results in a formative way and consider them in planning future teaching and learning activities;
- ensure that their assessment tasks include opportunities for learners to achieve at various cognitive levels;
- attend in-service OBA training opportunities and register for OBA courses related to Physical Sciences offered by universities or other institutions;
- lobby and put pressure on teacher unions to provide opportunities for further professional development in the field of OBA of Physical Sciences in FET Band;
- establish teacher networks both inside and outside the school for the purposes of collegial advice and assistance;
- liaise with parents on a regular basis to keep them informed about the assessment process, and their children's progress;
- become life-long learners and seize opportunities for continuous professional development.

Motivation

According to Meyer (2010:5) teachers must possess a thorough understanding of OBE and OBA to be able to successfully implement the OBA of Physical Sciences. They must be subject specialist and should be able to link this specialist knowledge with learning outcomes and assessment standards contained in the departmental curriculum statements. In essence, teachers should be flexible, innovative and creative when they use guidelines, and should add their own personal “flavour” to their assessment programme and strategies (Meyer, 2010:5). Moreover, teachers must strive for quality education at all times.

According to the Department of Education, all teachers and other educators are key contributors to the transformation of education in South Africa. In order to fulfil the mandate, the department needs teachers who are qualified, competent, dedicated and caring. These teachers should be mediators of learning, interpreters and designers of learning programmes and materials, leaders, scholars, researchers and lifelong learners (DoE, 2003a:5).

11.4 Recommendations for further research

This research was conducted in the North-West province, amongst teachers who taught Physical Sciences in the FET Band. Thus the findings of this research can neither be generalised to other provinces of the country, nor to the entire population of South African Physical Sciences teachers. Therefore it is recommended that the study should be replicated on a national sample of Physical Sciences Teachers.

Furthermore, the survey was conducted at the time when the Physical Sciences’ Curriculum and Assessment Statement (CAPS) was in the process of development and finalization. Thus, it is recommended that the national survey should be conducted on Physical Sciences teachers’ experiences of CAPS.

11.5 Concluding thought

Credibility, quality and efficiency are the principles on which South African education is based, that is, providing an education that is comparable in quality, breadth and depth to those of other countries (DBE, 2011:5). The researcher sincerely hopes that this research could in some way contribute towards this aim.

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APPENDICES

Appendix A: A letter requesting permission to conduct research within the Province

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Private Bag X6001, Potchefstroom
South Africa 2520

Tel: (018) 299-1111/2222
Web: http://www.nwu.ac.za

Science, Mathemetics & Technology Education
Tel: (018) 018 299 4271
Fax (018) 018 299 2421
EMail Nico.Morabe@nwu.ac.za@nwu.ac.za

Chief Operations Officer
Department of Education North West
Private Bag X2044
Mmabatho
2735

24 March 2010

Dear Sir

REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITHIN THE PROVINCE

I am currently a lecturer and registered PhD student at the North-West University, Potchefstroom Campus. I am currently conducting research that focuses on Outcomes-Based Assessment (OBA) of Physical Sciences in the FET band. I therefore kindly request your permission to conduct the research with Physical Sciences teachers within the North West province. The results and recommendations of the research will thereafter be made available to the teachers and the public at large.

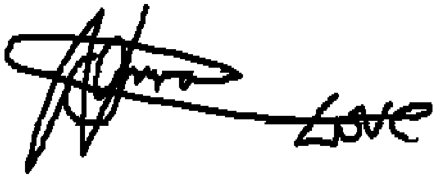
As schools will be randomly selected to participate in this survey, the following conditions apply:

- The respondent will complete the questionnaire on a voluntary basis.
- There is no harm to the respondent who will complete the questionnaire.
- All information will be treated as confidential.
- The respondent's identity will not be revealed and every respondent and school will remain anonymous.
- If the respondent completes the questionnaire, we accept that the participation in this research is voluntary.
- By completing the questionnaire, the respondent agrees to participate in this research.

The completion of the questionnaire will take the teacher approximately 15 to 20 minutes.

Your assistance in this regard will be highly appreciated as the outcomes of the research will help to improve Physical Sciences teachers' conception and application of OBA within the province.

Yours sincerely



ON Morabe
Lecturer

NICO.MORABE@NWU.AC.ZA c:\documents and settings\administrator\my documents\thesis 2010\permission to conduct research within the province.doc

Appendix B: A letter giving permission to conduct research within the Province

24-MAR-2010 13:54 FROM PHYSICS/SPACE PHYSICS TO 0343880866772915 P.01/01

education
Lefapha la Thuto
Onderwys Departement
Department of Education
NORTH WEST PROVINCE

Garona Building
First Floor
Private Bag X2044
Mmabatho 2735
Tel.: (018) 387-347[illegible]
Fax: (018) 388-[illegible]
e-mail: mphoentle@nwpg.gov.za

OFFICE OF THE CHIEF OPERATIONS OFFICER:
BRANCH: DISTRICT AND PROFESSIONAL OPERATIONAL SERVICES

Enquiries: Ms M.J. Mogotsi

24 March 2010

To: Mr N. Morabe
PhD Student
North West University: Potchefstroom Campus

From: Mr M.A. Seakamela
Chief Operations Officer
Districts and Professional Operational Services

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT RESEARCH: OUTCOMES-BASED ASSESSMENT (OBA) OF PHYSICAL SCIENCES IN THE FET BAND

Please be informed that permission has been granted for you to conduct research with Physical Science educators within the North West Province. Approval is therefore granted under the following conditions:

- That consultation with the schools/officials identified is done
- That any publication of information pertaining to the department should be done with the permission from the department
- That learning and teaching process is not compromised
- That service delivery is not compromised
- That the department be favoured with the outcomes of the research

Your input in contributing to the betterment of education is appreciated

Regards

Mr M.A. Seakamela
Chief Operations Officer
District and Professional Operational Services

"TOGETHER, DOING MORE, BETTER"

TOTAL P.01

Appendix C: A letter requesting permission to conduct research within your school

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
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EMail Nico.Morabe@nwu.ac.za@nwu.ac.za

The Principal
NWED Secondary School

Dear Sir/Mad

24 March 2010

REQUEST FOR PERMISSION TO CONDUCT RESEARCH WITHIN THE SCHOOL

I am currently registered as a PhD student at the North-West University, Potchefstroom Campus. My research focuses on Outcomes-Based Assessment (OBA) of Physical Sciences in the FET band. The attached questionnaire will enable me to gather valuable input on the research topic. Authorisation for this research was given to me by the Deputy Director General, North-West Department of Education (see next page). Your school was randomly selected as one of the schools in the North-West Province to participate in this survey. I therefore kindly request your permission to allow any one of your Physical Sciences teachers to participate in completing this questionnaire.

As your school is randomly selected to participate in this survey, the following conditions apply:

- The respondent will complete the questionnaire on a voluntary basis.
- There is no harm to the respondent who will complete the questionnaire.
- All information will be treated as confidential.
- The respondent's identity will not be revealed and every respondent and school will remain anonymous.
- If the respondent completes the questionnaire, we accept that the participation in this research is voluntary.
- By completing the questionnaire, the respondent agrees to participate in this research.

The completion of the questionnaire will take the teacher approximately 15 to 20 minutes.

Your assistance in this regard will be highly appreciated as the outcomes of the research will help Physical Sciences teachers with the effective implementation of OBA of Physical Sciences within the school.

Yours sincerely

ON Morabe
Lecturer

NICO.MORABE@NWU.AC.ZA c:\documents and settings\administrator\my documents\thesis 2010\permission to conduct research within the province.doc

Appendix D: Letter requesting assistance with data collection

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Private Bag X6001, Potchefstroom
South Africa 2520

Tel: (018) 299-1111/2222
Web: http://www.nwu.ac.za

Science, Mathematics & Technology Education
Tel: (018) 018 299 4271
Fax (018) 018 299 2421
EMail Nico.Morabe@nwu.ac.za@nwu.ac.za

The Physical Sciences Subject Advisor
North-West Province

24 March 2010

Dear Sir/Mad

REQUEST FOR ASSISTANCE WITH DATA COLLECTION

I am currently registered as a PhD student at the North-West University, Potchefstroom Campus. My research focuses on Outcomes-Based Assessment (OBA) of Physical Sciences in the FET band. The attached questionnaire will enable me to gather valuable input on the research topic. Authorisation for this research was given to me by the Deputy Director General, North-West Department of Education (see next page). School were randomly selected in the North-West Province to participate in this survey. I therefore kindly request your assistance with the distribution and collection of the questionnaire from the selected school within your area.

As schools are randomly selected to participate in this survey, the following conditions apply:

- The respondent will complete the questionnaire on a voluntary basis.
- There is no harm to the respondent who will complete the questionnaire.
- All information will be treated as confidential.
- The respondent's identity will not be revealed and every respondent and school will remain anonymous.
- If the respondent completes the questionnaire, we accept that the participation in this research is voluntary.
- By completing the questionnaire, the respondent agrees to participate in this research.

The completion of the questionnaire will take the teacher approximately 15 to 20 minutes.

Your assistance in this regard will be highly appreciated as the outcomes of the research will help to improve Physical Sciences teachers' conception and application of OBA within the province.

Yours sincerely

ON Morabe
Lecturer

NICO.MORABE@NWU.AC.ZA c:\documents and settings\administrator\my documents\thesis 2010\permission to conduct research within the province.doc

Appendix E: A letter to the Physical Sciences teacher

NORTH-WEST UNIVERSITY®
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Bussie 285

Fax: 018 299 2421

Private Bag X6001, Potchefstroom
South Africa 2520

Date: 14 May 2010

Dear Educator

Re: Request for participation in this research

I am currently registered as a PhD student at the North-West University, Potchefstroom Campus. My research focuses on Outcomes-Based Assessment (OBA) of Physical Sciences in the FET band. The attached questionnaire will enable me to gather your valuable input on the research topic. Authorisation for this research was given to me by the Deputy Director General, North-West Department of Education (see next page). Your school was randomly selected as one of the schools in the North-West Province to participate in this survey. I therefore kindly request your assistance in completing this questionnaire. The completion of the questionnaire will take you approximately 15 to 20 minutes.

Before completing the questionnaire, please take note of the following:

- You complete the questionnaire on a voluntary basis.
- There is no harm to you as respondent in completing the questionnaire.
- All information will be treated as confidential.
- Your identity will not be revealed and every respondent and school will remain anonymous.
- If you complete this questionnaire we accept that your participation in this research is voluntary.
- By completing the questionnaire you agree to participate in this research.

Your participation is highly valued and appreciated.

Kind regards

Morabe ON
(Researcher)

Appendix F: Questionnaire on OBA of Physical Sciences in the FET Band

QUESTIONNAIRE ON OUTCOMES-BASED ASSESSMENT OF PHYSICAL SCIENCES IN THE FET BAND

NB: This questionnaire must be completed by an educator who is teaching/has taught Physical Sciences to Grades 10 – 12 during the period 2006-2010

Complete the questionnaire by colouring the appropriate block of your choice on the computer card (items 1- 91) and by giving a written response in the space provided (items 1B1; 2B1; 1B2; 1B5 - 5B5; and 1B6 – 2B6).

NB: PLEASE ANSWER ALL THE QUESTIONS

SECTION A

Please provide the following information about yourself and your school:

1. Gender

1	2
Male	Female

2. Age in years

1	2	3	4	5	6	7
20 – 25 yrs	26 – 30 yrs	31 – 35 yrs	36 – 40 yrs	41 – 50 yrs	51 – 60 yrs	61+ yrs

3. Overall teaching experience in years

1	2	3	4	5	6	7
1yr	2 – 5 yrs	6 – 10 yrs	11 – 15 yrs	16 – 20 yrs	21 – 30 yrs	More than 30 yrs

4. Teaching experience as a Physical Sciences teacher in the FET band in years.

1	2	3	4	5	6	7
1 yr	2 – 5 yrs	6 – 10 yrs	11 – 15 yrs	16 – 20 yrs	21 – 30 yrs	More than 30 yrs

5. What is your highest teaching qualification?

1	2	3	4	5	6	7
Teaching Certificate	Teaching Diploma	Teaching Degree	B-degree + Teaching Diploma	Hons. Degree/ BEd.Hons	M.Degree + Teaching Diploma	Ph.D degree + Teaching Diploma

6. What is your highest qualification in Physical Sciences/Physics/Chemistry?

1	2	3	4	5	6	7
Grade 12	1st Year tertiary level	2nd Year tertiary level	3rd Year tertiary level	Hons. Degree	Masters Degree	Doctors Degree

7. What is your position at your school?

1	2	3	4
Teacher	Head of department	Deputy Principal	Principal

8. Is your school situated in a rural or urban area?

1	2
Rural	Urban

9. Is electricity available at your school?

1	2
YES	NO

10. Is running water available at your school?

1	2
YES	NO

11. Which grade/s do you teach Physical Sciences to?

1	2	3	4	5	6
Grade 10 only	Grade 11 only	Grade 12 only	Grades 10 and 11	Grades 11 and 12	Grades 10 – 12

12. The average number of learners in your Physical Sciences class is:

1	2	3	4	5	6
10 – 20	21- 30	31 – 40	41 - 50	51 – 60	61 – 70

13. Does your school have a science laboratory?

1	2
Yes	No

14. Do you have apparatus to do practical work (experiments) in your Physical Sciences classroom?

1	2
YES	NO

15. If you have science apparatus at your school, which apparatus do you have?

1	2	3	4	5	6	7
Standard science apparatus	Somerset Micro-kits	Student-Lab Small-scale set	None	All	2 and 3	1 and 2/3

16. Which medium of instruction do you use to teach Physical Sciences at your school?

1	2	3	4	5
English	Afrikaans	Alternating between English & Afrikaans	Alternating between English & Setswana	One of the other official languages

SECTION B

QUESTIONS ON OUTCOMES-BASED ASSESSMENT (OBA) OF PHYSICAL SCIENCES IN THE FET BAND

B1: OBA training and confidence to implement OBA

Please answer the following questions with regard to OBA training and your confidence to implement OBA:

17. Did you receive training in OBA?

1	2
YES	NO

18. For how long did you receive training in OBA?

1	2	3	4	5	6	7
A few hours	1 day	2 days	More than 2 days	1 week	More than 1 week	NA

19. At what level was the OBA training presented?

1	2	3	4	5	6	7
School level	Area office level	Regional level	Provincial level	National level	Union	Other institution

20. How do you rate the standard of OBA training that you have received?

1	2	3	4	5	6
Very poor	Poor	Above Average	Good	Very Good	N/A

1B1. If you have marked **very poor or poor** for item 20 above, please motivate your response in the space below:

Reasons why I rated the standard of OBA training that I received as very poor/poor:

21. How confident are you to implement OBA in the FET band?

1	2	3	4
Not confident at all	Not confident	Confident	Very confident

2B1. If you have marked **not confident at all or not confident** for item 21 above, please give reasons for your lack of confidence below:

***Reasons for my lack of confidence to implement OBA in FET band*:**

B2: NCS documentation

Please answer the following questions with regard to NCS documentation:

Which of the following NCS document(s) are you familiar with?

NCS Documents (Grade 10 - 12) : Physical Sciences	**1**	**2**	**3**
	Yes	**No**	**Not sure**
22. Learning programme Guidelines			
23. Subject statement			
24. Subject assessment guidelines			
25. Assessment policy framework Grades 10 -12 (General)			
26. Examination guidelines (Grade 12)			

Which of these documents are available to all teachers at your school?

NCS Documents (Grade 10 - 12) : Physical Sciences	**1**	**2**	**3**
	Yes	**No**	**Not sure**
27. Learning programme Guidelines			
28. Subject statement			
29. Subject assessment guidelines			
30. Assessment policy framework Grades 10 -12 (General)			
31. Examination guidelines (Grade 12)			

Which of these documents you personally have a copy of?

NCS Documents (Grade 10 - 12) : Physical Sciences	**1**	**2**	**3**
	Yes	**No**	**Not sure**
32. Learning programme Guidelines			
33. Subject statement			
34. Subject assessment guidelines			
35. Assessment policy framework Grades 10 -12 (General)			
36. Examination guidelines (Grade 12)			

What is your opinion of the above NCS documents?

	1	2	3
	Yes	**No**	**N/A**
37. They are easy to understand			
38. They contain clear guidelines for implementation			

1B2. If you have marked **no** for item 37 or 38 above, please give reasons for your responses below:

***Reasons why I am of the opinion that the NCS documents are not easy to understand and/or do not contain clear guidelines for documentation*:**

B3: Statements on OBA departing from an OBE perspective

Please respond to the following statements with regard to OBA:

39. Assessment is primarily the teacher's task.

1	2	3	4
TOTALLY DISAGREE	DO NOT AGREE	AGREE	AGREE COMPLETELY

40. Assessment is a new concept that was introduced by OBE.

1	2	3	4
TOTALLY DISAGREE	DO NOT AGREE	AGREE	AGREE COMPLETELY

41. Teaching, learning, and assessment are seen as separate processes within the OBE framework.

1	2	3	4
TOTALLY DISAGREE	DO NOT AGREE	AGREE	AGREE COMPLETELY

42. Critical and developmental outcomes should be contextualized within the framework of learning outcomes and assessment standards.

1	2	3	4
TOTALLY DISAGREE	DO NOT AGREE	AGREE	AGREE COMPLETELY

43. Departing from an OBE approach, learners should be aware of assessment criteria before any assessment activity can take place.

1	2	3	4
TOTALLY DISAGREE	DO NOT AGREE	AGREE	AGREE COMPLETELY

B4: Assessment of Physical Sciences in the FET Band

Please answer the following questions with regard to the assessment of Physical Sciences in the FET Band:

To what an extent are your assessment activities designed to provide learners with the opportunities to acquire and develop the following skills/abilities:

	1	**2**	**3**	**4**
Skills/abilities	To no extent	To a small extent	To a considerable extend	To a large extent
44. Practical, scientific and problem solving skills				
45. The ability to construct and apply scientific knowledge				
46. The ability to identify and critically evaluate the contested nature of science and its relationships to technology, society and the environment				

To what extent do your assessment activities aim to:

	1	**2**	**3**	**4**
Aims:	To no extent	To a small extent	To a considerable extent	To a large extent
47. develop learners' knowledge, skills and values				
48. assess learners' strengths and weaknesses				
49. provide additional support to learners				
50. revisit or revise certain sections of the curriculum				
51. motivate and encourage learners.				

To what extent do you consider the following principles of high quality assessment when you plan assessment tasks?

	1	**2**	**3**	**4**
Principles of high quality assessment	To no extent	To a small extent	To a considerable extent	To a large extent
52. Reliability				
53. Validity				
54. Authenticity				

To what extent do the following assessment strategies contribute towards the effective assessment of Physical Sciences in the FET band?

	1	2	3	4
Assessment strategy (method/technique)	To no extent	To a small extent	To a considerable extent	To a large extent
55. projects				
56. presentations				
57. debates				
58. simulations				
59. assignments				
60. case studies				
61. essays				
62. practical tasks				
63. performances				
64. exhibitions				
65. research projects				
66. tests				
67. examinations				
68. portfolios				

To what extent does the following list of continuous assessment (CASS) benefits contribute towards the effective assessment of Physical Sciences in the FET phase?

	1	2	3	4
List of CASS benefits	To no extent	To a small extent	To a considerable extent	To a large extent
69. It provides teacher with reliable information of learners progress because their learning is regularly assessed throughout the year				
70. Learners set their own individual goals because they are involved in self-assessment				
71. It furthers learners' growth and development because they become active participants in the learning and assessment process				
72. It provides feedback on the quality of learning and teaching				
73. It allows for ways of giving feedback to learners about what was achieved by the assessment activity				
74. It allows for different assessment strategies				

75. It provides for a variety of learner needs through utilization of assessment strategies that				
76. It promotes valid and reliable assessment				
77. A more extensive sections of the curriculum can be covered by means of CASS				
78. Skills and concepts that are difficult to assess in examination/test situations can be assessed by means of CASS				

79. Do you regard the OBA practice of assigning 25% to CASS and 75% to the summative assessment of Physical Sciences in the FET Band to be a fair practice?

1	**2**	**3**
Yes	No	Not sure

B5: Experiments and practical work

Please answer the following questions with regard to conducting experiments and other practical work in Physical Sciences:

80. How regularly do you instruct your learners to conduct experiments?

1	2	3	4
Not at all	1 every term	1 every two terms	Before/after a concept was taught

1B5. If you have marked option 1 (not at all) to item 40 above, please give reasons why your learners do not conduct experiments in the space below:

My reasons for learners not conducting experiments:

To what extent do you use the following strategies to teach learners scientific inquiry skills during practical work?

	1	2	3	4
Strategies to teach learners scientific inquiry skills	Not at all	To a small extent	To a considerable extent	To a large extent
81. Demonstrations				
82. Hands-on experiments (Being done by learners themselves)				
83. Simulations (of experiments)				
84. Multimedia presentations (e.g. DVD, Video of experiments)				

2B5. If you have marked **not at all, or to a small extent** to any of items 81, 82, 83, or 84 above, please provide reasons in the space below.

***My reasons for not using, or inadequately using strategies to teach learners scientific inquiry skills during practical work**:*

To what extent do the following problems/challenges prohibit you from using practical methods (e.g. experiments) when you are assessing your learners in Physical Sciences?

	1	**2**	**3**	**4**
Problems/challenges	Not at all	To a small extent	To a considerable extent	To a large extent
85. My lack of training in practical work				
86. The lack of resources at my school				
87. My inability to design assessment instruments that assess learner performance at different cognitive levels across all the Learning Outcomes				
88. My fear of causing accidents when practical work is done				
89. Insufficient time for doing practical work				
90. Lack of knowledge of practical aspects and scientific inquiry				
91. Lack of Departmental support (workshops)				

3B5. If you have marked **to a considerable extent or to a large extent** to any of items 85 to 91 above, please provide reasons in the space below.

Reasons why certain problems/challenges prohibit me from using practical methods (e.g. experiments) when I am assessing my learners in Physical Sciences:

4B5. Please explain how you usually assess your learners' practical work in the space below.

How I usually assess my learners' practical work:

5B5. Please state your opinion about the moderation of practical work by subject specialists, in the space below

***My opinion about the moderation of practical work by subject specialists*:**

B6: Further comments and suggestions about the OBA of Physical Sciences in FET band

1B6. Please give some further comments on the OBA of Physical Sciences in FET band, in the space below:

Positive comments:
Negative comments:

2B6. What can be done to improve the OBA of Physical Sciences in the FET band? Please write down your suggestions in the space below:

Suggestions:

Thank you very much for your participation

APPENDIX G: Verbatim responses to open-ended questions

Responses to Item 1B1

If you have marked very poor or poor for item 20 above, please motivate your response in the space below. (20. How do you rate the standard of OBE training that you received?)

- Limited time frame
  - the training was done theoretically
  - demonstrations should have been done in class with the learners to see if OBE is possible
  - Training was done by our teacher colleques whom in my opinion I think they find it difficult as well.
- I still have a lot of problems in understanding the underlying principles of AOB. It appears the actual AOB we talk about is not the one that is in place at the moment. The learning is not learner centred.
- Content went out the back door. That still remains the most important issue!!! Many teachers are not capabale to handle the new content, what will the learners learn? How are you suppose to get 70 – 80% for a subject that your teacher knows 40 – 50% off??
- It was a crash course and not a detailed developmental workshop as we expected, since this was a completely new concept.

Responses to 2B1
Reasons for my lack of confidence to implement OBA in FET band: (not confident at all or not confident to implement OBA of P/S in FET band)

- NOT SURE WETHER I'M DOING THE RIGHT THING OR NOT.
- - I have not received any training which can help me to confidently implement OBA.
  - The educators who have attended some workshops say they were not given feedback on the assessments that they did, therefore they do not completely understand want OBA is about.
- Maybe I should not be so very confident. Because the question is: Am I really doing the correct thing according to the books.
- With the method, learners seem not to relate well with the teacher.
  -learners cannot work on their own even with guidance or supervision.
- Still struggling – to design practical investigation.
- If one is not properly trained, there is no way one can implement or impart information to others or put to practice what one has learned.
- Our trainers themselves were not that confident while rendering training.

Responses to 1B2

Reasons why I am of the opinion that the NCS documents are not easy to understand and/or do not contain clear guidelines for documentation:

- ❖ Guidance are complicated; for implementation; too much information and too much paper-work.
  - Too much time is wasted on paperwork rather than teaching.
- ❖ They are missing the point. We want more technicians, engineers etc. At the moment or the current trend we will definitely end up with less. We will still have doctors and engineers but no technicians, no fitters, and tuners and electricians.
- ❖ Content is too much to complete very well. Very detail ensuring learners understand it very well and can apply. Too long content too little time.

Responses to1B5

My reasons for learners not conducting experiments:

- There are no resources which are sufficient for all learners to carry out experiments and even a demonstration by the educators.
  The equipment in the lab is not working or the chemicals have long expired
- OBA training not offered at all.
- There is no water in the laboratory, most chemicals are expired.
- My reason for learners not conducting more experiments: Being the H.O.D. I am moderating work of other educators which is using up a lot of unnecessary time. Impromptu-to meetings at school and other nitty gritty's is consuming time which I could have channeled into preparing more experiments
  A few years back we had to do 8 experiments per year, I remember it taking ±1 hour to prepare the apparatus & worksheets beforehand.
  I will gladly do it in stead of checking other teachers' work who gets paid for doing their work.
  The most Physics and Mats Educators I have met are H.O.D's, the administration is taking us out of classes! HELP!!!
- 1- every term > There is a mobile laboratory which visit the school once a term.
  - school do not have a laboratory.
- Inadequate apparatus
  No laboratory
  No DVD
- Experiments depends on the type or content being taught at that point in time, some are difficult to undertake due to lack of appropriate resources, whereas some content is purely theoretical.
- The only time available is for teaching. The educator is after covering the bigger scope of the schedule and the time is very short.
  Learners are doing many subjects which consume the time that learners could be using to conduct experiments.

The syllabus is also too long and need more time to cover it – on the other side learner should also be assessed and time is also needed for that.

- NO LABORATORY
  LIMITED SCIENCE EQUIPMENTS AND LIMITED ACCOMODATION.

Responses to 2B5

My reasons for not using, or inadequately using strategies to teach learners scientific inquiry skills during practical work:

- Learners watch DVD (normally) for revision after completion of the syllabus.
- LIMITED RESOURCES.
- DUE TO LIMITED RESOURCES AND OVERCROWDING IN CLASS.
- The school currently does not have the necessary resources i.e projector, DVD, software for simulations and multimedia presentations.
- No video of experiments and no DVD's.
- Not in possession of relevant, science DVDs and Vedios.
- Resources are not adequate
  Laboratory not standard
  Apparatus just packed i.e labs not functional only improvisation.
- We don't have the resources at school. It can't be done, because we don'nt even have projectors at school. If similations are shown, it is done on a laptop. Not all the learners can see it.
- DVD AND VEDIO OF EXPERIMENTS NOT AVAILABLE AT SCHOOL. THE SCHOOL CAN'T AFFORT THEM SINCE IT IS A RURAL SCHOOL FOUND IN A VERY POOR COMMUNITY.
- SCHOOL DOES NOT HAVE, A TV, DVD PLAYER.
- No resources available to be able to perform this task.
- Teaching time is very short and with the kind of learners I have, they are very slow so more concentration or more focus is ensuring that they understand scientific concepts and are able to apply them to solve scientific knowledge.
- Most often than not is due to lack of equipments to use.
- Limited space > class overcrowdings
  - no laboratory, no chemicals
  - for proper demonstration, or hands-on experiment to be done learners need to travel to nearby education centre; it consume time; cause conflict with other teacher to take learner away for a day or two.
- They are not equipped enough to work on their own
- There is a serious want of such material. Efforts to obtain such, has been futile.
- Overloaded with learning areas.
- I wish to have projectors and screens with a computer to show learners some experiments.
- TIME! Syllabus too long!
- Not able to access multimedia.

- IN OUR SCHOOL (MORE ESPECIALLY IN OUR DEPARTMENT WE DON'T HAVE THOSE RESOURCES LIKE OVERHEAD PROJECTOR. SO THAT ALL THE THINGS CAN BE VISIBLE, AUDIBLE TO LEARNERS.
- Know about simulations but do not have access to it. We do not have it at our school. The department have not made it available anywhere that we can have access to.
- The unavailability of D.V.D.'s, vedio cassettes, and a D.V.D. player
- The educator is teaching different subjects and different grades. He is after the completion of the syllabus. There is minimal time for allowing larners to perform the practical. The educator is focusing on the knowledge and content of the subject matter
- THE SCHOOL DOES NOT HAVE NECESSARY EQUIPMENTS TO CAN USE MULTIMEDIA PRESENTATION.
- Ek het nie internet in die klas tot my beskikking nie.
  Ek het 'n voorraad van ou video's, maar beperkte hoeveelheid of geen DVD's.
  Ek sal graag nuwe programme oor die sillabusihoud wil kry, die skool het egter nie geld om dit aan te koop nie.
- We were not workshopped on simulations. I therefore have no idea what simulations on experiments are all about. I really did not do simulation in class or in the laboratory.
- Lack of time is reason. For using such strategies, at least 1 hr is needed. Single periods are not enough to carry out this (I have only one double period a week).
- LACK OF THIS FACILITIES DVD AND VIDEO'S.
- Our school is not equipped with multimedia resource.
- Multimedia or DVD etc are only used if the real practical work cannot be done.
  I use the above mostly for enrichment.

Responses to 3B5

Reason why certain problems/challenges prohibit me from using practical methods (e.g. experiments) when I am assessing my learners in P/S.

- ❖ There have not been any recent workshops on conducting practicals within the area office. More resources are needed in the schools especially chemicals for chemistry experiments.
- ❖ No enough apparatus chemicals expired.
- ❖ Teaching load is too much. Preparation for expts and demonstrations requires time and also clearing up the set up. Without a lab assistant while teaching more than two science classes, its difficult to manage.
  Sometimes consumables like batteries may not be readily available because of the beauracratic process of procurement at the school.
- ❖ The school timetabling 35 min period with one double is not enough.
- ❖ The Resources is not available at school. There is also not enough time to teach. As it is it is necessary to teach on Saturdays.
- ❖ THE SCHOOL DOES NOT HAVE A LAB AND CARRYING APPARATUS FROM STOREROOM TO CLASSROOM IS JUST A MAMMOTH TASK.

- TIME, TIME, TIME
  - As H.O.D I am responsible for the timetable which changes a lot because due to lack of Departmental policy
  - Educators come and go as they wish they do not give a quarter times notice.
- Lack of chemicals and laboratory.
  - small classrooms with large capacity of learners in each class (overcrowding).
- The laboratory does not have some of the materials to conduct practicals.
- 1) The school does not have enough space ro do practical work with learners
  2) One cannot focus on one learning area due to heavy work load, teaching of more than one learning are.
  3) Rural schools seem to get less attention of Departmental Officials especially subject specialists.
- We, teachers (especially Gr:12) struggling to finish the syllabus in every term. Hardly no time for revision before each term exam. Learners are very slow in learning and we need more time to finish the theory and other CASS components.
- Less contact time i.e. A period takes 30 minutes, so I find it difficult to teach and do experiments at the same time. Even though I sometimes use study time. I'm not alone who sees these learners during that time. We have a study-timetable where I sometimes see them after a week. We do have the Saturday lessons of which I sometimes use them for the practicals, the problem is that the learners don't call f them and I have to postpone to the school days/week days where they'll all be present.
- Time! Syllabus too long and too difficult especially in grade 10 it takes a lot of time for learners to grasp the new work. Gap between grade 9 and grade 10 very big. If the learner thought in grade 9 he can do Physical science it does not mean he actually can do it in grade 10.
- Do not have enough apparatus.
- Some of the experiments takes time and the periods are not …

Sometimes a teacher get angry if learners come to his/her class late after a practical lesson. Even if you discuss before the lesson some feel you want to make your subject better. Most of the time the practical work & cleaning up can be done within an hour. Occasionally you need 5 or ten minutes extra and that discourages a person. The planning and preparation takes lots of time without an assistant.

- Lack of resources:- chemicals, apparatus such as voltmeters are not up to date and not available at all.
- The Department has since supplied many equipments to schools, to operate some of these equipment teachers need to be workshoped. There have never been a workshop on how to handle some new apparatus as a result they are gathering dust and turning into white elephants. This is the biggest weakness of the department after spending millions on apparatus.
- 89 - MOST EXPERIMENTS NEED MORE TIME AND THE SCHOOL'S TIME-TABLE DO NOT CATER ENOUGH TIME FOR PRACTICALS.
  91 – THE DEPARTMENT DOES NOT PROVIDE SUPPORT IN TERMS OF WORKHOPS, PARTICULARLY ON PRACTICALS AND PROVISION OF EQUIPMENTS AND CHEMICALS.

- ❖ My fear on item 88 based on that I don't want to put life of the learners in danger, because they have good future ahead about science.
- ❖ Workschedule for Physical Science are so conjested and in most cases we rush to finish the workshedule and overlook practical work.
- ❖ Since there is no laboratory in our school, some of the laboratory equipments are unavailable and there is a problem of chemicals that are finished in as far as chemistry is concerned and in Physics esp. electricity the batteries have run out before we can use them. The are no manuals to operate some equipments, hence lack of departmental support.
- ❖ (1) NO LABORATORY.
  (2) INSUFFICIENT SCIENTIFIC APPARATUS.
  (3) LACK OF CLASSROOMS OR EMPTY ROOMS.
- ❖ Time to do practical work is limited, in actual fact, there is no time to do practical work. Workshops have to be perpertualy done by the department to enhance educator training because education is dynamic nowadays, i.e. changes now and then.
- ❖ Die nuwe sillabus is werklik te' oorvol met al die nuwe teoriese feite en kennis wat ons moet oordra. Ek dink werklik die werkinhoud moet verminder word, soda tons weer die geleentheid het on basiese konsepte en praktiese voordighede behoorlik aan die leerders oor te dra en aan te leer soos in die verlede.

Responses to 4B5

How I usually assess my learners' practical work:

- Assess learners'participation, how they handle apparatus, presentation of results, interpretation of findings, accuracy and by rubric – N.B Conclusion. (evaluation).
- USE RUBRIC TO ASSESS LEARNERS'
- BY USING MEMORANDA AND RUBRIC
- I usually use rubric which scores them on different aspects such as ability to work neatly, efficiently, without much assistance etc, ability to construct investigative questions, hypothesis and interpretation of data collected.
- Use the rubric and the memo.
- Mostly demonstration – where learners respond to questions.
  Experiments – guided questions based on an experiment.
- By making use of a RUBRIC which clearly states that a learner is going to get a mark when the/she did these and no mark when these is not done. The RUBRIC clearly states the teacher expectations and it is given to learner beforehand for him/her to be able to see what is it that is expected from him/her.
- Group work practical involving manipulation of apparatus and the writing of an experimental report after /use a rubric to mark.
- By doing a practical investigation and assessing it by using a rubric.
- USE A RUBRIC IN ORDER TO ACCOMMODATE ALL THE SKILLS NECESSARY FOR PHYSICAL SCIENCES.
- Use rubric in which I assecess the following

Are learners able to – plan (1) state the question
(2) hypothesis
(3) aim
- Design (1) list the apparatus
(2) outline procedure
- Execute practical
(1) follow procedure and do practical
(2) observe and record results
(3) analyse results
(4) Drew conclusion

- Practical assessment is an interactive process that consider wide variety of skills such as be able to use apparatus wisely, meeting instructions well, co-operating, taking part, etc and a tick and wrong cannot always apply therefore we use a marking grid in graphs or rubrics as well as marking guideline as well as a memorandum.
- Learners are put into small groups of 5, with each provided with a work sheet; with clearly defined steps.
- The use of rubrics and also using the peer assessment.
- With the limited space and apparatus (science lab) I normally assess the learners in groups.
- By reading through what they have done and also by using a rubric.
- I normally usually use the rubrics it is:-
  1) Rubric for conducting experiment where I focus on the skills of handling the apparatus and using them appropriately, the skill of following instruction properly and making good observations, and also focus on whether learners are able to understand or interpret what is happening or interpreting results from observations made.
  2) Secondly it is the rubric for written report of experiment which assess the skills of learners of reporting the results and whether they are able to conclude base on results.
- On – investigative question
  On – hypothesis
  On – apparatus used
  On how to handle their risks on chemicals – laws at science laboratory
  * method to solve problems
  *results
  *interpretation of results
  *discussion and conclusions
  - when answering – look at the rubric to guide them (steps).
  -
- Observe their practical work – use rubrics – mark their report on the practical work – use rubrics.
- Give them instruction to follow and then observe as they are in action.
- They are given questions and answers i.o.w. a worksheet.
  -when the demonstration is done some more questions is asked to the group.

-The learners are also asked to work in groups e.g. build an electric motor with the kit provided.

- Give learners practicals questionnaires or tutorial for the preparation of the practicals.

  - with valid instruction and intense supervision learner perform their experiment with help of mobile lab from University of Pretoria.
- They are assessed on their ability to conduct practicals, measurements, setting up apparatus and collecting data.
- By use of a rubric and by observing them while they perform.
- RUBRIC, MEMO
- Provide learners with work sheets all the materials and then monitor for safety reasons, most practicals are done in groups.
- Learners are given rubric which is going to help them to know exactly on what are they going to be assessed.
- Use a rubric to assess the practical work.
- Practicals investigations are assessed with rubricks.
- By using memo and rubrics.
- I give them rubric and explain it

  While they are busy with the experiment, I assess certain skills, such as handling of apparatus. Graphs, tables and other information are assessed after they have completed.
- I demonstrate the practical while explaining and then hand over to them to do the experiment on their own while they are also recording results on their recording sheet.
- I explain to them some concepts pertaining to the chapter or the experiment and what they must do, Assessment Standard. I then ask them to collect the apparatus and write report:

  i.e. Investigative question and hypothesis
  Write down the apparatus & chemicals to be used.
  Write the method and observations
  Write variable (if applicable) and then conclusion.

  I also design a rubric and explain it to the learners so that they know what is expected and what to do, even a memorandum if there are questions asked.
- Using rubric for assessing: - Planning
  Hypothesis
  Method
  Research
  Graph, Tables
  Conclusion
- Use rubrics for each individual learner

  Asses them while they are busy with the experiment as well as the report they hand in.
- AFTER EVERY PRACTICAL WORK I ASSESS MY LEARNERS, IN TERM OF FOLLOWING THE NEEDS OF PRACTICAL WORK, AND OFTEN.

- I use RUBRIC or/or checklist, go around while they do the practical work and assess how they handle and use the apparatus as well as method followed. Learners are given worksheet to complete and/or write up a REPORT.
- Use of memorandum and rubric
- I usually assess the practical work using memos and rubrics. They do the practical work, I assess them using the rubrics.
- Learners are divided into groups if the resources are available. If the resources are not enough, demonstration is done by the educator.
- I divides them in small group in order to simply my work when assessing them. Make sure that they perform experiments correctly, hence I'm going around each group when they are busy performing experiments and intervene where necessary and when the error or common difficulties encountered.
- I USUALLY ASSESS MY LEARNER'S PRACTICAL WORK USING BOTH A RUBRICK AND MEMORANDUM.
- The educator should use the memorandum and the rubric. The memorandum is used to mark the practical work. The rubric is used to consolidate the memorandums or the practical work.
- I use memorandum to mark learners work and allocate a mark, thereafter I use rubric(s) and again allocate a mark.
- M.bv. Rubriektabelle, Tutoriale toetse, Vraelyste, Werkkaarte.
- I usually use a rubric or a checklist.
- Rubrics (sometimes memorandum also)
- (1) Give them a short test (theory) on the previous work.
  (2) To explain the set up of the experiment and the methods.
  (3) Observation and Analysis of results.
- I assess my learners' practical work by means of a worksheet that I have complete during the practical. I also spend a lot of time going around to their groups while they are busy to see if all learners in the group is involved, and also to address any questions that may arise while the learners are busy. It is also very important for me not to immediately answer the learners questions, but to help them change their point of perception.
- Learners work in groups but report as individuals. I always use a rubric and an attached memorandum to check their knowledge of theory against the practical work.
- For practical investigations and research a problem is stated to the learners. They then get a period of time to plan the investigation – The rubric were given to them with the problem statement. Their planning is then assessed by myself and suggestions will be made by me. Then the investigation will be done while I am observing. A report is written and then the lot (report, observation, skills etc) are assessed by myself using the rubric.
- I usually draft a rubric that is relevant to what is been assessed.

Responses to 5B5

My opinion about the moderation of practical work by subject specialists:

- In our area office we conduct a common practical investigation, but conduct various practical work at school level.
- SPECIALIST SHOULD ALSO USE THE TOOL USED BY EDUCATORS.
- DO NOT ASSESS TO A GREATER EXTENT
- They do a thorough job by carefully checking if learners conducted the experiment on their own and were able to report on the experiment.
- Fair enough, as they assist in terms of the rubric for marking.
- Is that it is fair and done well since it conforms with regulations and guidelines spelt in the various documents.
- Subject specialist do moderate practicals and they take a closer look at the rubric and marks allocated to learners. The practical activity is then discussed and where possible they (specialists) together with educators come up with other possible ways of doing that practical. What is interesting is that the APO educators agree on common practicals per grade. Practicals are not just done but they are done per agreement.
- It is Good but it is only forcast on one aspect – report writing.
  Visit to schools by specialists to see learners doing the practicals is a good idea which gives a clear and correct picture of it all.
- It feels that midyear moderation is too late.
  Moderation must take place in the year.
  Meetings must be called in January so that all teachers know exactly what is expected from them
- IT IS UP TO STANDARD.
- It is well and the only challenge might be the practicals are not easy to be made at all time since the school does not have laboratory and some of the chemicals are old.
- The moderation of practical work is a noble idea, though it does not have any bearing on overall learner performance.
- Moderation is always fair, since we use the same practical documentation and the same work schedule. It also check if the teacher are following the work schedule and according to the work schedule.
- It benefits the educators a lot, shortcomings are highlighted during the course of the moderation and in this way the educator/educators will not commit the same errors.
- They are supportive and also assist us educators in terms of implementing cass correctly and to the fullest.
- He always ask the rubric first and need all the necessary steps to solve the problems.
- It’s difficult for S.S to do moderation of practical parts of practical work. They can only control the instructions given to the learners and the final report written by learners.

- We have very few subject specialist because in many instances we have the same understand of the subject and technical know how to improve approaches to the teaching of the subject.
- The subject specialist does not visit us often enough.
  - But with the final moderation emphasized that the educator must remember about the hypothesis.
- It is efficient, as it help educators lay out well structured questions for practicals, which in turn helps learners in an exam.
- Is good, they do give insight into what should be done right.
- It's necessary and well-done.
- HELP IN DESIGNING PRACTICALS TO BE DONE FOR EACH LEARNING AREA.
- Some subject specialization do not have clear understanding of certain practicals and at the end they create confusion due to their adherence to their regid moderation instrument.
- They usually assess marks not necessarily whether the practical work was done correctly.
- Very good, 'cause He checked whether the practical work has the investigative question, state the hypothesis and check the procedural of the practical work.
- It is done once a year.
- Subject specialists never satisfied by the rubrics, unless they must provide their own. Even if we are using the rubrics provided by the provincial CASS document, still complaints are their solution is, department must give us the clear guideline about each terms practicals and rubrics. As a science teacher, I like experiments than practical investigation.
- Moderation is done properly.
- We don't have a practical moderation per ser. We only have quarterly CASS moderation.
- Very vague, three people can give three different marks! There is no way to compare mine with the next schools. Practicals rather be set externally like grade 12 November exam then everybody are tested on the same level!
- Don't have a problem with it.
- EXCELLENT WORK, DONE BY SUBJECT SPECIALISTS.
- PRACTICAL WORK IS ONLY MODERATED IN GRADE TWELVE (CASS) DURING MODERATION OF CASS MARKS.
- This can be done twice per term.
- Sometimes it is not up to scratch because it is late to send the teacher back to do another practical.
- The moderation is fine. The subject specialist are helping and advising the educator on how to mark the practical work. This is also the empowerment on the side of the educator.
- SUBJECT SPECIALIST ONLY COUNT THE MARKS ALLOCATED TO CHECK ONLY IF THE MARKS TALLY WITH THE MARK SHEET.
- I think she is fair to us, hence they are some practical that come from region (circuit). She always motivate us for how to handle or done practical with learners.

- It is fair since after moderation, challenges are outlined, guidance is provided and to certain extent practical work and rubrics are provided by the Specialist.
- I personally feel that moderation of practical work by specialists should differ according to the type of school they moderate. The school which do not have a laboratory with all the equipments is not the same as the one which do not even have a lab. It becomes very difficult for the teacher to do the experiments if the school do not have necessary equipments.
  If the teacher improvise, then the specialists doing moderation, they usually question what is been done by the teacher. They usually come there as fault finders but not to assist so they are making our lives very difficult. They will be questioning your assessment and they are never satisfied but not all the subject specialist are behaving like that.
- Clear instructions about what a investigation should entails and what a research project should be like must be given to National. I am a Provincial SBA moderator and most of the investigations that I had seen cannot even pass as practical work. Only when everybody knows what is expected can moderation be meaningful.
- My subject specialist moderates the practical work very well and he even gives suggestions on how to deal with the matter.
- It is valuable asset for the educator, because it help to identify problem areas for your own improvement.
- -It is considerably fair
  -it helps the educators not to forget practicals and emphasize only theory.
  -it helps to balance theory and practice which helps learners not to forget what they have learnt easily.
- moderation of practical work is done fairly, they are given priority than other components.
- If I have to rate subject specialist moderation of practical work, I would say excellent!!! Their moderations has helped me a great deal!!!!!
- Goed.

Responses to 1B6

Positive comments on the OBA of Physical Sciences in the FET band:

- 1. To judge effectiveness of learning programme
  2. Help learners improve their work.
  3. Helps to diagnose problem.
  4. Help learners to improve their work.
- Learner centred
  Promotes learner participation 3.g Science Expo
  Learners can create their own knowledge.
- It gives educators an opportunity to know the relevant document to CASS and what is expected of them.
- OBA encourages learners to be involved in the learning process. !
  OBA gives a reliable assessment since its continious.

- Learners are engaged in practicals as they are part of CASS components.
  Do required projects.
- Quite a good strategy to teach using objectives ie you have got a standard by which you assess the learner and also yourself as a teacher.
  The content is clear although lack of coherent from Grade 11 to 12.
- It is nice to do, if the learners know what to do.
  Good way of assessing learners.
- ASSISTANCE IN THE DRAWING/MARKING OF WORKSHEETS FOR PRACCTICAL PURPOSES.
  ASSISTANCE IN COMPILING RESEARCH PROJECTS (Guidance FOR THE PROJECTS TO BE GIVEN TO GR10 – 12 LEARNERS)
  SUPPLY SCHOOLS WITH PREVIOUS QUESTION PAPERS (last year) Including MEMOS. And examiners report:
- Learners are aware of assessment strategies before he perform a task.
- Is quite fair the only challenge that we have is the generation of today who are less interested in education yet there is quiete enormous opportunity for them. Generally is a well organized and wholestic process.
- The content is alright.
- It helps the learners to know their strengths and weaknesses. It gives, all the learners an opportunity to achieve at their own pace.
- It assist in the attainment of quality results.
- OBA is good since it helps to prepare learners for the future by providing them skills that will help them in the scientific environment. It allows learners with different opportunities (assessment opportunities) to pass their studies. It also helps the educator to understand the weaknesses and strength of his/her learner. It also allow learners to make individual assessment to understand their weakness and strength.
- * I have learned that there are different perspectives as objective knowledge.
  * It has provide the experiences to motivate on different perspectives and make choices in building your own subject knowledge that will direct your role as Physical Sciences teacher at school.
- Learners enjoy the practical work.
- The number of assessment tasks are easy enough to complete.
  - I really simplifies assessment.
  - I do find it not overburdening.
- It helped learners to develop his drawing skills.
- It could work on small average classes.
    - learners are given opportunities to research or do work on their own
    - It helps learners to relate on Science and everyday life (LO3).
- It covers all aspects off the curriculum to equip learners with skills.
- It does ensure competent learners and professionals are produced, since the standard is high.
- LEARNER GET USED TO PRACTICAL
- 1) Process skill were used

2) critical thinking, scientific reasoning and strategies were used to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.

- Assessment is satisfactory.
- It is a life-long learning
  Assessment criteria is discussed with learners before
  It is learner-centred
  To a considerable extent learners can link knowledge gained at school with real life situations
  Feedback is done in a discussion form in which it serves as a lesson again
- Challenging, interesting.
- I MAT THE GOOD ASSESSMENT THAT CAN HELP TO PUT ON PHYSICAL SCIENCE IN FET ON THE GOOD TRACK AMONG OUR LEARNER'S WORK; ALSO IN TEACHING.
- It gives feedback to the learners, parents
- Assessment is excellent.
- The type of assessments are good and are both learner/teacher oriented.
- ,ajoritty of educators were trained on OBA. Policies and necessary documents on OBA are available in school and we are aware of them. More information is provided by specialist during workshops and PSFs.
- At least majority of Physical Science educators were trained about OBA. It clear up misconceptions about assessment. Taught educator of previous years about the new curriculum. Emphasize a point of learner centred.
- It is helping the educator to cover all the learning outcomes during teaching. The educator not to teach the knowledge only. It also help the learner to be developed in totality. The learner to relate the learning content into reality or real life environment
- It is a yardstick that can be used to measure how far learners are, their weaknesses and the idea of performance at the end of the year.
- Learners are highly involved. They work on their own at their own pace. It promotes mutual cooperation.
- CASS gives the teachers reliable information about the learners progress because they are assessed regularly through out the year.
- The importance cannot be over-emphasized.
- I think the OBA of Physical Sciences (FET) is good for both the learner and educators. It helps the educator to monitor the performance of the learners throughout the year and in every module of the learning are. The educator can evaluate the learners easily and learners also are able to assess themselves and their peers even the parents are involved in the children's education.
- More skillfull candidates can be produced if all the skills are developed. The syllabus however is too crowded to do practical work intensively.
- Learners are actively involved in learning because it gives the learner to participate in their own learning.
  There is a continuous assessment throughout the year and hence it gives the learner the opportunity to know when and where the learner did not understand.

Negative comments on the OBA of Physical Sciences in the FET Band:

- Less content in terms of Physical Sciences assessment is assessed. E.g Inorganic chemistry is omitted etc.
- Educators lack enough content
  Constructivism is not possible within limited resources e.g.
  Educators feel pressurized because it needs a lot of time but at the same time work schedule has to be completed.
- The quality of work is not been checked.
- OBA – encourages rote learning only and does not encourage independence in learning since the aim is on the outcome.
- Practicals are to be done but the Department does not see to it that schools have necessary and relevant resources for those required practicals.
- Lack of coherent of concepts. Concepts that are asked in Grade 11, are not in Grade 12 at all which implies to wide concepts for the learner that understanding is difficult
- I have to take much more time to explain to learners what and how to do it, even after all instructions were given.
- ASSESSMENT IS NOT EFFECTIVE BECAUSE OF THE RUSH TO COMPLETE THE WORK SCHEDULE AS EXPECTED. FOR EXAMPLE GRADE 11 WORKSCHEDULR IS JUST TOO LONG TO BE COMPLETED IN ONE YEAR AND LEAVES NO ROOM FOR EFFECTIVE ASSESMENT.
- It take a long time and it impacts on the completion of the work schedule and pace setters. Weak learners hide behind learners who are gifted. It does not give the true reflection of the actual marks obtained by the learners.
- Weaker learners suffer with the work. If they are in the same group as stronger learners they just copy the work. Practical work must be done after school hours – sometimes difficult because of sport activities.
- Not enough preparations was done by those in power or those who understand it better.
- Because of the minimum of 2 practical investigations one tends to relax and always feel guilty that more could have been done.
- Waste of time, Paper and **resources**
  - No time to teach
  - Time is wasted on preparing uses statics and other office documents
  - Teachers are degraded into mere office clerks.
  - No effective teaching and learning.
  - Learners lost the culture of learning
  - Learners become lazy
- Very difficult to implement.
  - No sufficient resources in many school.
  - Most of our learners do not understand method of questioning as they can read well.
- Some of the questions are way above the comprehension of our learner (black) in disadvantaged school because of language barrier.

- Too much is expected in very little time in terms of content to be covered and mastered by the learners.
- LEARNERS NOT INTERESTED IN LEARNIG
- To design tasks.
- SKVA
  Skills expected to be acquired have limited application in real life situations
  Knowledge in FET is beyond learners' level
  Values of OBA in FET is vague, we have 2 assessments in Physics and Chemistry and not all chapters cater for LO3.
  Attitude – the curriculum itself doesn't encourage learners to become future scientist
  Group assessment is not always beneficial.
- Syllabus too long, don't cater for electricians and other technicians learners don't want to take the subject because of the difficult. Other subjects were made more easy for instance he can easily obtain a distinction in languages, business studies, life sciences, etc. but definitely NOT in physical sciences.
- Syllabus too full and extensive – no time to help the children with difficulties. For grade 12 the percentage composition faulty. The research assignment counts more than an exam that test knowledge and insight? How does that work?
- Learners are only interested and puts effort in ONLY the assessment that counts for their term/year mark, i.e. the prescribed ones. Other (informal) NOT part of CASS do not really reflect learners true potential. Because they do not prepare for it.
- Time frames should be controlled and sometimes a solution is needed before you check on the outcomes. Learners need to pass sometimes you wait for the outcomes when the whole group has failed. A balance must be set up between performance and outcomes.
- It gives everybody the opportunity to pass including those who are not doing enough or even deserving to pass. It involves so much time and paperwork which reduces contact time.
- Lack of training to some educators and insufficient time that gave the educators.
- Assessment tool and how to design a practical investigation is still a nightmare to a certain extent.
- It is a disadvantage to those learmner who do not have laboratories, equipments and libraries. It becomes difficult for those to do practical work, as for research projects, they do not have the access to some important information which can only be accessed a library eg. Internet, etc.
- Learners are not commited.
- 1) Do not give learners enough time to be taught.
  2) Learners assessed without preparing adequately.
- A lot of paper work.
- - Die sillabus is te' oorval. Jy kry glad nie kans om basiese konsepte in te oefen by die leerders nie
    - Hulle weet op die ou end te min van enigiets, want hulle verloor moed.
    - 3 verpligte projekte is te veel per jaar en dit vat baie tyd vir leerders om navorsing te doen, waar hul eerder kon leer en vrae kan uitwerk.

Responses to 2B6

What can be done to improve the OBA of Physical Sciences in the FET Band? Suggestions:

- Expose learners to more content, like previously (old syllabus), more work was done.
- Assess your own teaching regularly
  - give feedback timeously.
- More resourceful laboratories are resource centre need to be set up.
  Teacher:learner ratio needs to be reduced to make practical teaching more effective.
- The instrument must be discussed with educators, so that they must know exactly what is expected of them as far as assessment is concerned.
- Provide more resources
  Familiarise the educators with the system (OBA).
  Provide training for implementation of projects, investigations, and practical research.
  Remove common tasks like June exam – gives unnecessary pressure to learners and educators.
- Science is more based on activities that learners can do (known to unknown).
  Schools do have laboratories and some equipment but not all equipments.
  The Department should visit schools and see what is it that the school needs in their laboratories for practicals to be done.
- Structure the content with practical activities and according to the exam guidelines – that everything is studed in the hope to meet it in Gr 11.
  - reduction in the number of content subjects to three so that learners can at least specialize and be more focused on a few things, when energy is spread over a number of subjects, understanding of concepts becomes limited since things are generalized that the syllabus be completed.
  - Deeper analysis and understanding of concept needs time and focus and practice at the same time.
- More resources can be given to schools. The department can provide everything to the schools.
  Chemistry and Physics should be 2 different subjects.
- FROM EXAMINERS REPORT, TRAINING CAN BE CONDUCTED IN ORDER TO ADDRESS THE SHORT COMINGS AND IMPROVE THE SUBJECT KNOWLEDGE OF EDUCATORS.
- Much is done
- 1) conduct a seminar or a symposium of some kind to get an overview for general views of the educators. This can stretch up to entire country educators as we are experiencing different problems based on our different situations.

  2) Have interaction with other performing schools, to expose our learners to different environment or atmosphere.
- 1) MATRIC EXAM TO BE WRITTEN IN TWO YEARS.

2) RESTRUCTURING THE EXAMINATION PAPER, SO THAT FOR STRUCTURED QUESTIONS LEARNERS ARE ABLE TO CHOOSE QUESTIONS.

- Minimise the number of learners in class to be able to give them individual attention to learners.
- I suggest that teachers should teach learners to participate in group and to discover on their work they are doing.
  * Work harmoniously in groups
  * Learners hear other learners' suggestions.
- More qualified educators (for Physical Sciences) per school.
  When you must teach P.S. to four different grades you want to run away!!
- Change the promotion criteria in the GET band because it is the one that is failing the grade 10's when they get to FET. Back to basics PLEASE!!!
- If School Administration can be streamlined. Not so many times ordering of textbooks and lot of questionnaires that has to be filled then educators will have more time at hand to spend on quality teaching.
  Eg. Instead of ordering the learners portfolios I could be revising for them.
- Bring back learning and teaching contents with practical
  - no research projects.
  - Change the cass Ratio
  - Practicals must be evaluated individually
  - Regular lists and examinating
  - Propositions must be based on practical lists and examinations
- More teachers should be hire.
  - one teacher should be responsible for only one grade per learning area for thorough preparations.
  - It must be practiced thoroughly from lower classes.
- Questions must be in simple language and case studies must be familiar to our learners.
- Teacher training by competent facilitators.
- Provision of sufficient lab material.
- Provision of relevant custom designed simulation and DVDs.
- DO PRACTICAL INVESTIGATION, RESEARCH, PROJECTS, INVOLVEMENT IN SCIENCE EXPO
- Those in the Physical Sciences stream must be give a chance to offload some subjects in grade 10 and the specialize in Physics as pure, Chemistry as pure and mathematics in grade 11 and 12. This will ensure more time for them to complement well advaced practicals together with detailed theory.
- Educators be taken to workshops regularly for assistance in different topics.
- 1) More practical workshops
  2) seminars
  3) more materials to be provided.
- Programme of Assesment must have a pre-designed lesson practical investigations i.e. per core knowledge area.

Lesson plans be "ready made" and correlate with the work schedule though we are told to plan according to the environment yet examiners do not consider the environment factor.
We prefer one prescribed textbook especially for the learners.
We must have a stable policy that is not revised timeously.
The recording sheets must be revised to cater for tasks suggested above.
The DoE must involve different stakeholders who are in Science field to visit schools in order to arouse learners' interest in science and also develop educators.
Let each prescribed practical investigation have its prescribed rubric with the memo included if possible.

- Streamline the syllabus, other subject standard must be higher not lower!!!
- Admin → "pink" files with requirements that keeps the teachers so busy to windowdress in order to keep Umalusi happy is taking up valuable teaching time.
- TEACHERS MUST BE WORKSHOP THOUROUGHLY AND ALSO BE APPLIES THOROUGHLY.
- To maintain a balance between performance and required outcomes in order to avoid failure. Teachers must perform well and learners must be prepared to pass.
- Workshops to be conducted every term to accommodate newly appointed educators.
  - practical investigations to be designed by the Province (Specialists) and provided to school to ensure a required standard in all the schools.
  -
- they suppose to request problems that encountered on physical science in various school; and then make workshop in order to resolve those common difficulties encountered by various educators. Make this training of OBA in every quarter or term. Make sure that every educator is well trained about OBA.
- More time be allocated to P-science like Maths to enable educator to have enough time to perform practicals. Laboratory educator also be introduced and work in laboratory only to perform practicals for learners.
- 1) for the first three terms learners must be assessed on examinations (control tests) only and not include components like projects, etc.
  2) only at the end of the year it is then that the whole CASS can be implemented.
  3) level 2 (30 – 39)% (F) should not be considered as a pass.
- -skaal asb die totale hoeveelheid werk af.
  -Konsentreer ook op die basiese voordighede wat hul in Fisika en Chemie nodig het in gr 10 – 12, wanneer die leerinhoud van die junior fases beplan word.
  -Beperk die projekte vir CASS tot slegs een projek so dat ons meer informeel dagliks praktiese ondersoek en demonstrasies kan doen.
  -Laat genoeg tyd toe om basiese vaardighede vir leerders in te oefen.
  -Die vrae moet voorsiening maak vir sterk leerders asook vir die leerder wat sukkel of implimenteer asb weer 'n HG en SG fase.
  -Sommige werk is werklik te moelik vir die gemiddelde leerder om op skool te verwerk.
- Decrease paperwork or paper work to be done by department and teachers to teach only. Assistant teachers to be employed by the department so that they can take care of the paper work.

- Making the resources available in all schools (where physics is offered by learners)
  Making arrangements to replace the chemicals (when they are used up).
- I am of the opinion that learners are struggling in the F.E.T. phase because they do not spend enough time mastering the basics of Physical Science during the 8th and 9th grades.
- The curriculum especially in grade 11 physical science is too large and there is no time to explain everything in details. Some topics should be of self-study.
- The Cass mark is compiled through the year and then amounts to 25% of the final mark and the exam 75%. That percentage must be carried the same way through the whole year when reporting per term. E.g. The first term practical work amounts to 80% of the report card mark and Tests 20% etc. At the end of the year this compiled mark is related to exam mark. Only the top candidates will correlate. This produces a problem for averages etc.

ooOoo

Appendix H: A letter from NWU Statistical Consultation service

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOMKAMPUS

Privatebag X6001 Potchefstroom 2520
Tel (018) 299 1111 Fax (018) 299 2799
http://www.puk.ac.za

Statistical Consultation Services
Tel: (018) 299 2016

Faxs: (018) 299 2557

8 August 2012

To whom it may concern

Re: Thesis Mr N Morabe, student number: 1700629

We hereby confirm that the Statistical Consultation Service of the North-West University has analysed the data and assisted with the interpretation of the results.

Kind regards

DR S M ELLIS Pr Sci Nat

Head: Statistical Consultation Services

Appendix I: A checklist for LOs and ASs for Physical Sciences

Check list for Learning Outcomes and Assessment Standards for Physical Sciences

Grade: __________________ Year: ________________

LEARNING OUTCOME 1: Practical Scientific Inquiry and problem-solving skills. The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.																				
Learning Cycle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ASSESSMENT STARDARDS																				
Plan a scientific investigation																				
Conduct a scientific investigation																				
Collect data systematically and accurately provide reliable information																				
Able to control one variable																				
Seek patterns and trends in information collected																				
Linking collected information to existing scientific knowledge																				
Draw conclusion																				
Apply given steps in a problem-solving strategy to solve standard exercises																				
Communicate information and conclusions with clarity and precision																				
LEARNING OUTCOME 2: Constructing and applying scientific knowledge The learner is able to state, explain, interpret and evaluate scientific and technological knowledge and can apply it in everyday contexts.																				
ASSESSMENT STANDARDS																				
Recall and state basic prescribed scientific knowledge																				
Discuss prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other																				
Apply scientific knowledge in familiar, simple contexts																				
Categorises information																				
Finds information from other sources																				
LEARNING OUTCOME 3: The nature of science and its relationships to technology, society and the environment The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development.																				
ASSESSMENT STANDARDS																				

Discuss knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge																				
Describe the interrelationship and impact of science and technology on socio-economic and human development																				
Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on the immediate environment.																				
Suggests ways in which to improve technological products																				

APPENDIX J: A list of laboratory safety rules

A LIST OF LABORATORY SAFETY RULES

- Observe all instructions given by the teacher. Ask for help when you need it.
- Always wear safety clothes when entering the Laboratory (e.g. goggles, laboratory coat, hand cloves).
- In case of an accident, report to your teacher immediately.
- Be careful in using flames. Keep clothing away from the flame, and do not use flame near inflammable liquids.
- Follow the directions carefully when handling all chemicals.
- If acids or bases are spilled, wash immediately with plenty of water. Be sure you know where the neutralizing solution is located in the laboratory. Ask your teacher how to use it.
- Read the labels on all reagents carefully. Make a habit of reading each label twice on any reagent used in an experiment.
- Dispose of waste materials in the proper receptacles. Solid materials should be placed in special crocks provided for the purpose.
- Be sure you know the location and proper usage of the fire extinguishers, fire blankets, eyewash, and shower provided in the laboratory.
- Do not eat or drink in the laboratory.
- Avoid tasting or sniffing chemicals.
- The laboratory should always be locked when not in use.
- Put equipment and chemicals safely away.
- Wear goggles.
- Wear laboratory coat.
- Be sure to identify your safety your safety equipments.
- Consider the laboratory a place for serious work. There is no excuse for horseplay.

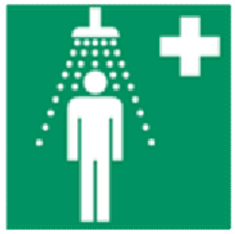
APPENDIX K: Laboratory safety symbols

Laboratory Safety symbols

The symbols below are adapted from the following site:

http://Chemistry.about.com/od/healthsafety/a/aa080104a.htm


Eyewash Sign or Symbol


Safety Shower Sign or Symbol


First Aid Sign


Defibrillator Sign


FireBlanket Safety Sign


Radiation Symbol


Biohazard


Radioactive Symbol


Ionizing Radiation Symbol


Recycling Symbol


Skull and Crossbones


Toxic


Harmful or Irritant


Flammable


Explosives


Oxidizing


Corrosive

APPENDIX L: Learner's personal information

Learner's Personal Information

Learner registration No: ___________________

Surname: ______________________________

First Names: ____

Sex (mark) : Boy: _____________ Girl _____________ Date of birth: ___________________

Residential Address: ____

____

____

Postal Address (If different from residential): _______________________________________

____

____

Home language: _______________________________________

Parents:

Father's name: _____________________________ Mother's name: ________________________

Surname :______________________________ _______________________________

Work Tel: ______________________________ ____________________________

Cell number: _____________________________ ____________________________

Next of kin (or Guardian): ____

Work Tel: ________________________________Cell number: __________________________

Name of medical Scheme:____________________ Medical aid number: ____________________

Family doctor: ________________________ Tel number: _____________________________

Allergies:

____

Preferred sitting row (mark) : Front Middle Back

Reactions: ____

Ailments: ____

Sensitivity to strong chemical smells: ____

Signature: _____________________________________

APPENDIX M: Form to be completed by the learner at the beginning and end of each learning cycle

Form to be completed by the learner at the beginning and end of each circle

Setting Aims

My learning aims for this circle are:

I want to learn how to:

- ……………………………………………………………………………………………
- ……………………………………………………………………………………………
- ……………………………………………………………………………………………
- ……………………………………………………………………………………………

I want to improve on:

- ……………………………………………………………………………………………
- ……………………………………………………………………………………………

REFLECTION

In this circle I have learned how to

- ……………………………………………………………………………………………
- ……………………………………………………………………………………………

Two stars and one wish –

I give myself two stars for:

➢ ……………………………………………………………………………………………

➢ ……………………………………………………………………………………………

I wish to

○ ……………………………………………………………………………………………

I rate the enjoyment level of the cycle as: (tick the appropriate face)

(Adopted from Reynecker, 2002)

APPENDIX N: Checklist and rating scale for peer assessment of learner's table

Checklist and rating scale for the peer-assessment of learner's table

Name of learner: ____ Grade 10

Name of assessor: ______________________________ Date of assessment: _________________

The learner has to tabulate the ingredients found in each of 6 home mixtures found at home.

A. Checklist

Assessment Criteria	**Performance indicator levels**			
	YES	**NO**	**Ticks**	**Comments**
Suitable heading for the table describing variables			2	
Descriptive column headings			6	
Descriptive row headings			5	
Units in heading, not in body of table			2	
Format of table			5	
Information in body of table			2	
Correct information in body			35	
TOTAL				

B. Rating Scale

I rate the learner's table as: (tick in the block next to the selected face)

Very Good		
Good		
Average		
Poor		

C. Feedback

I give the learner Two stars for:

____

____

____

One thing that the learner can do to improve is:

____

____

APPENDIX O: Worksheet 1 for experiment 1 on paper chromatography & Memorandum

Worksheet 1
(Adopted from Du Toit & Du Toit, 2001)
Experiment 2

How can you use Chromatography to separate dye colours in water soluble ink?

Learner(s') name(s): ____

____

____

____

Grade: __________________________ **Date:** ______________________________

Activity 1

Which separation technique can be used to determine what colour mixture each of the water soluble ink pens (red, brown and orange) contain?

Apparatus:

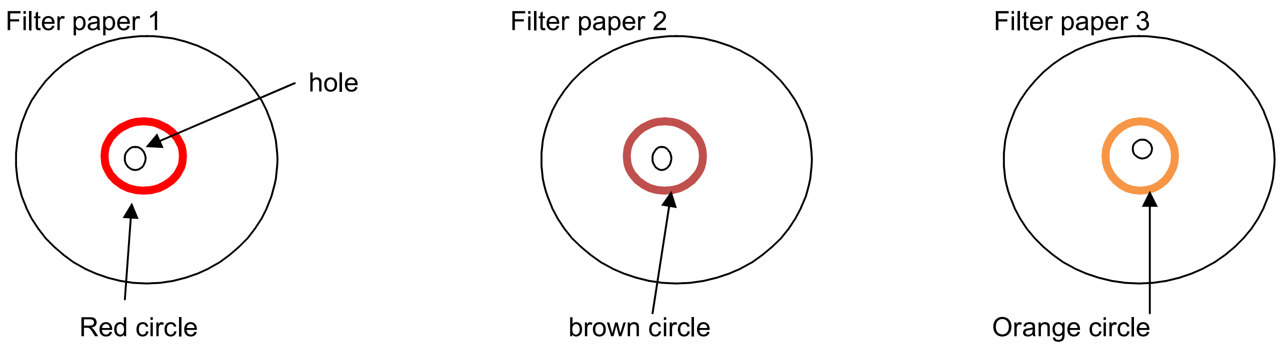
3 x glass beakers or test tubes, 6 x filter papers, 1 x nail

Chemicals: water

Extra: Water soluble pens (i.e. red, brown, and orange), scissor and pair of divider

Method

1. Collect three pieces of small filter paper.
2. Label them 1, 2, and 3. (M)
3. Use a pair of divider to draw a small circle around the centre of filter paper 1. Repeat this for filter paper 2 and filter paper 3.
4. Use the pair of divider to punch a small hole through the centre of each filter paper. (M)
5. Use red water soluble pen to trace the circle around the centre on filter paper 1. (M)
6. Use the brown water soluble pen to trace the circle around the centre on filter paper 2. (M)
7. Repeat the same with filter paper 3, this time using orange water soluble pen. (M)



8. Take another 3 clean filter papers and roll each in a tight cylinder (see Fig. 1). Insert each filter paper cylinder into the hole through the filters (see Fig.2 and 3). (M)

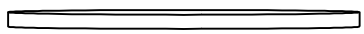


Fig. 1

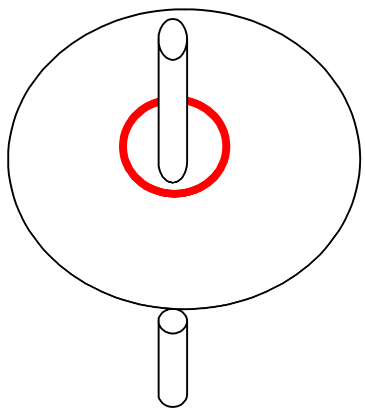


Fig. 2

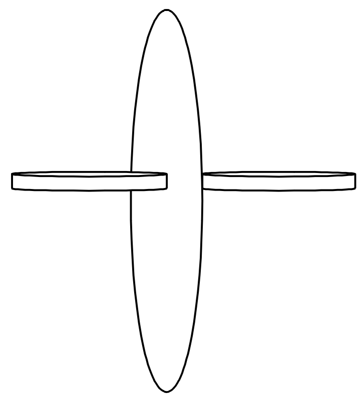


Fig. 3

9. Pour about ¾ of water each of the 3 glass beakers (or test tubes).
10. Place filter paper 1 with the red circle over the beaker (or test tube) in such a way that only the tip of the rolled filter paper is in the water and acts as a capillary tube (see Fig 4). (M)

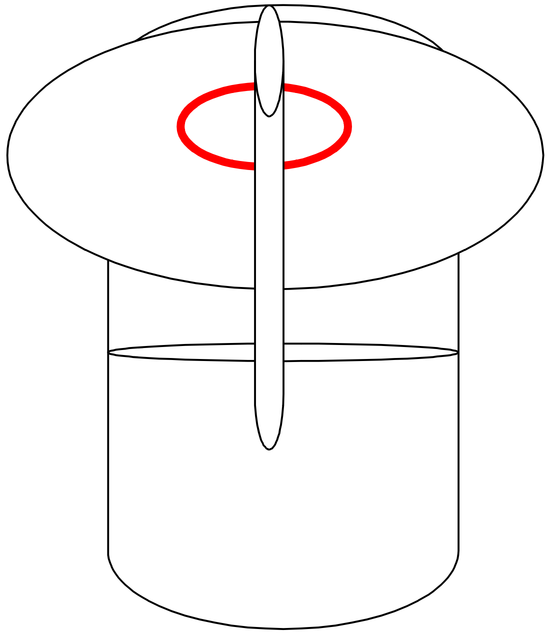


Fig. 4

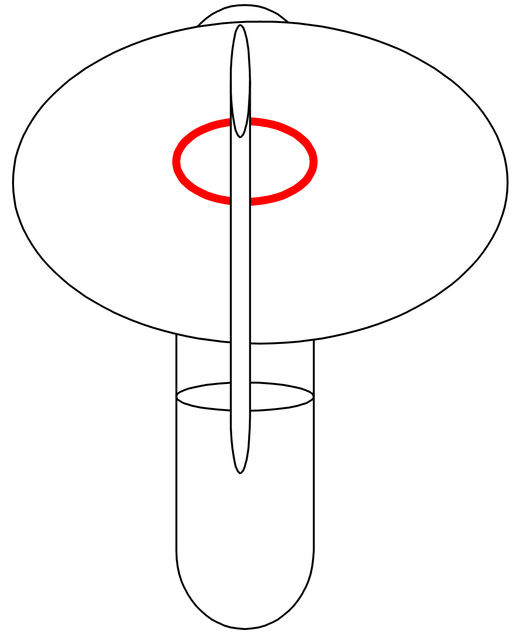


Fig. 4

11. Let the glass beaker (or test tube) stand for a few minutes until the solvent boundary is near the paper rim.

    Remove the paper circle and allow it to dry.

    Describe the colour pattern you observed. (o)

12. What did you observe on the filter paper 1? (o)

13. Place filter paper 2 with the brown circle over the glass beaker with water and it stand for a few minutes until the solvent boundary is near the filter paper edge.

    Remove the paper circle and allow it to dry.

    Describe the colour pattern you observe. (o)

14. Place filter paper 3 with the orange circle over the glass beaker with water and let it stand for a few minutes until the solvent boundary is near the filter paper edge.

    Remove the paper circle and allow it to dry.

    Describe the colour pattern you observe. (o)

15. Did the three ink mixtures contain the same dye colours? (o)

16. Was the above separation technique successful? Explain your response. (i)

17. What is your conclusion about the physical properties of the different participating substances (colour components) of the mixture (dye colour) in the above separation? (i)

18. Will this separation technique work to separate the ink mixture of your ball point pen? (Try it if time allows). (i)

19. What do we call the separation technique used in this activity? (k)

20. How many different chromatography methods do you know about? List them below. (k)

Wash hands on completion of experiments!!!!!!!

Appendix O (continued.)

Memorandum

1. What did you observe on the filter paper 1? (o)

Three circles (pink, yellow and red) formed spreading out from the centre to the outside of the
filter paper.

2. Place filter paper 2 with the brown circle over the glass beaker with water and it stand for a few minutes until the solvent boundary is near the filter paper edge.

   Remove the paper circle and allow it to dry. (M)

   Describe the colour pattern you observe. (o)

Three circle (pink, yellow and blue) formed spreading out from centre to the outside of the filter
paper.

3. Place filter paper 3 with the orange circle over the glass beaker with water and let it stand for a few minutes until the solvent boundary is near the filter paper edge. (M)

   Remove the paper circle and allow it to dry. (M)

   Describe the colour pattern you observe. (o)

Three circle (pink, light yellow and dark yellow) formed spreading out from centre to the outside
of the filter paper.

4. Did the three ink mixtures contain the same dye colours? (k)

No, the three mixtures did not contain the same dye colours.

5. Was the above separation technique successful? Explain your response. (i)

Yes, the separation was successful. The different dye colours were separated on the filter paper
in their colour components. The mixture of the colour components gives the specific dye, for
example, red or brown or orange

6. What is your conclusion about the physical properties of the different participating substances (colour components) of the mixture (dye colour) in the above separation? (i)

The dye colour (mixture) must be soluble in water in order to move along with water

7. Will this separation technique work to separate the ink mixture of your ball point pen? (Try it if time allows). (i)

No. because the ink mixture of my ball point is not soluble in water. The ball point ink will not
Move with the water, but will stay where it was applied to the filter paper.

8. What do we call the separation technique used in this activity? (k)

Paper chromatography.

9. How many different chromatography methods do you know about? List them below. (k)

1. Paper chromatography
2. Gas-liquid chromatography
3. Thin layer chromatography (TLC)
4. High pressure liquid chromatography (HPLC)
5. Column chromatography
6. Supercritical-fluid chromatography
7. Ion-exchange chromatography

Appendix P: Learner practical work self evaluation form

Learner Practical work Self Evaluation

The learner must complete the following table on conclusion of the practical.

6 – agree completely; 5 – agree; 4 – agree with reservations; 3 – undecided; 2 – don't agree; 1- definitely don't agree

	6	**5**	**4**	**3**	**2**	**1**
I cannot answer the questions						
I can follow the working instructions						
It is easy to see what happened in the experiment						
It is difficult to explain what happened						
I can now answer all the problem question						
I cannot find the same activities in my everyday life						
It is easy to work with apparatus						
I like doing experiments						
I am afraid to work with chemicals						
I can follow all the safety precautions						

(Du Toit & Du Toit, 2001)

Appendix Q: Teacher's evaluation sheet

Facilitator evaluation

1 – poor; 2 – awkward; 3 – clumsy; 4 – reasonable; 5 – good; 6 – very good;

	Observation (o)	Measuring (m)	Recording (r)	Manipulation (m)	Inferences (i)	Procedure (p)	Investigation (iv)	Evaluation (e)	Knowledge (k)
Question number									
Mark									
Total mark									

(Du Toit & Du Toit, 2001)

Appendix R: Worksheet 2, experiment 2 on properties of metals used in industry

How are the properties of metal used in industry?

Learner(s') name(s): ____

____

____

____

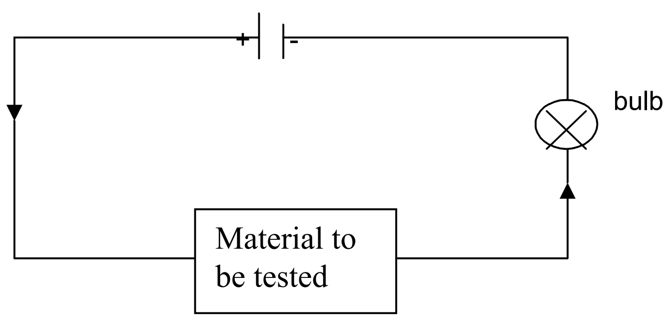
Grade: ________________________ Date: ____________________________

Apparatus

1 x glass beaker; 1 x copper electrode; 1 x zink rod; 1 x aluminium rod; 1 x glass rod; 1 x lead; 1 x test tube; 1 x 3 conductors/connecting wires; 9 volts battery; 1.5 A bulb;

Activity A: Investigating the conductivity of various solids

1. Assemble the series circuit like the one in the diagram below;



2. Connect the following materials between the clips one after the other and test for its conductivity: copper wire/pipe; zink rod; plastic ruler; pencil lead; silver or gold ring; aluminium foil; glass; piece of wood; (or any materials available in your school). Tabulate your results on a table.

3. Does the bulb glow when this material is connected to the circuit? (tick what you observe)

Material	**Yes**	**No**
1. Copper		
2. Zink		
3. Plastic ruler		
4. Pencil lead		
5. Silver/gold		

6. Aluminium		
7. Piece of wood		
8. Steel		
9. Lead		

4. Which materials are conductors? List

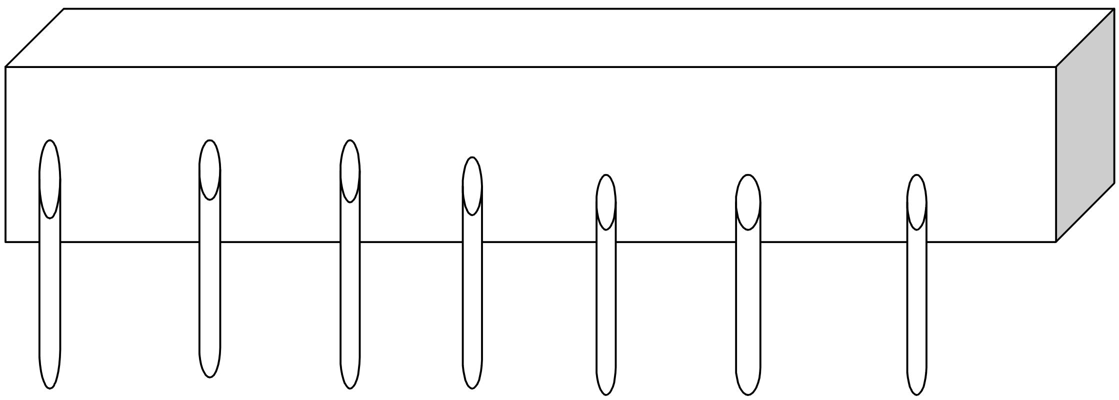
5. Which materials are semi-conductors? list

6. Which materials are insulators? List

7. What other possible action can be used to test for the conductivity of the materials?

Activity B: investigate which materials are thermal conductors and insulators

1. Boil about 500 ml of water in the kettle or glass beaker.
2. Test the heat conductivity with the apparatus as shown in the picture below.
3. Insert the material through the rubber seal in the heat conductivity apparatus or an ice-cream container made from a strong plastic can be used as a makeshift hot-water container. Make holes in the plastic container, push the rods through the holes and seal with Prestik.
4. Coat the rods with wax or Vaseline.
5. Pour hot water in the apparatus and observe the rate at which the wax or Vaseline melts on the various rods.



Copper Zink aluminium steel glass plastic wood

6. Record your results on the table below. The rod where the Vaseline drops off first is the best thermal conductor and must be recorded as 1 then one that follows should be 2 etc.

Metal	**Thermal conductivity**
1. Copper	
2. Zink	
3. Aluminium	
4. Steel	
5. Glass	
6. Plastic	
7. Wood	

8. Look at the table above. What are your conclusions about the thermal conductivity of the different materials?

Activity C: Investigate the magnetic properties of various solids

1. Collect a wide variety of metals and alloys. These should include iron; nails; steel pins; paper clips; cutlery of various types; silver; gold and platinum jewellery; a selection of cold drink cans; a selection of coins and any other metallic object.
2. Try to pick up the metal objects with a strong magnet. A loudspeaker contains a permanent magnet and can be used if an ordinary magnet is not available.
3. Complete the table below:

Material	Magnetic	Non-magnetic
1. Silver		
2. Gold		
3. Platinum		
4. Cold drink can		
5. Iron		
6. Copper		
7. Zink		
8. Cadmium		
9. Aluminium		
10. Gallium		
11. Lead		

4. What do you observe about the magnetic ability of the different metals and metal objects?

5. Can you explain your observations in 4 about the magnetic ability of the metals?

6. What are sonorous materials?

7. Which substances/materials are sonorous?

8. Why are metals sonorous?

9. What is an alloy?

10. What do you do with alloys in everyday life and why do you need alloys?

11. Give an example of an alloy you use in your everyday life.

ooOoo

APPENDIX S: Worksheet 3, experiment 3 on phase change of water

Experiment 3: Phase changes of water

3.1 Temperature curve of water

AIM:

To determine the effect of heat transfer on the temperature of water:

METHOD:

1. Half fill a beaker with cold water. Measure the temperature of the water with a thermometer.
2. Heat the contents of the beaker over a Bunsen burner. Stir constantly. Read the temperature every 30 seconds and record it in a table.
3. Keep on heating and recording the temperature minutely until the water boils for three minutes. Do not alter the intensity of the flame to ensure constant heat flow.
4. Represent your results on a graph of temperature against time.

RESULTS:

Time (min)															
Temp (^0C)															

Time (min)															
Temp (^0C)															

Time (min)															
Temp (^0C)															

GRAPH of temperature vs. time: (On graph paper)

RESULTS AND CONCLUSIONS

1. How does the temperature change when heat is transferred and

(a) the ice melts

(b) only water is in the beaker:

(c) the water boils?

2. What can we deduce from the form of the graph when heat is transferred to water below boiling point.

3. What can we deduce from the form of the graph when the water is at boiling point?

4. Shortly discuss the differences in your outcomes when boiling water in the laboratory and at home.

Appendix T: Observation sheet to use in the assessment of group work

OBSERVATION SHEET TO USE IN THE ASSESSMENT OF GROUP (DISCUSSION OR PRACTICAL) WORK

NAMES OF GROUP MEMBERS:

____

____

____

____

TOPIC OF DISCUSSION: ____

DATE OF GROUP WORK: ________________________RADE: __________________

NAME OF ASSESSOR: ____

GROUP ASSESSMENT	Performance indicator			
	1 - 2	3 - 4	5 - 7	Comments
1. Does the group understand the task?				
2. Do the learners work cooperatively?				
3. Does the group work through the procedure in orderly manner?				
4. Does the group utilise allocated time efficiently?				
5. Are apparatus used correctly?				
6. Are results recorded in most appropriate way?				
7. Results/Final product				
8. Response to questions based on experimental work				
9. Who takes the lead in the group?				
10. Who does not take part?				
Possible reasons for the group to function/does not function well:				

Appendix U: Checklist and rating scale for peer-assessment of learner's poster

Checklist and rating scale for the peer-assessment of learner's poster

Name of learner: ____ Grade 10

Name of assessor: ______________________________Date of assessment: _________________

A. Checklist

Criterium	**Rating**			
	1	**2**	**3**	**4**
Heading	No descriptive	Partially descriptive	Fairly descriptive	Very descriptive
Print size / font	Too small / font not appropriate	Too small but clear font chosen	Some large enough, clear font	All large enough to read at 1 m. Clear font
Organization/ layout	Muddled	Some organisation evident	Organisation clear and logical	Organisation clear and logical. Well designed
Use of pictures	No pictures	Pictures not used to good effect	Picture used to good effect	
Use of colour	Poor. One colour used	More than one colour used but not to good effect	Good colour usage	Excellent use of different colours and contrasts
Content – main points	Points selected irrelevant	Some points irrelevant	Points selected relevant	All main points included
Facts / concepts	Facts incorrect	Some facts incorrect	Facts correct	All facts correct and concepts clear
Expressing facts	Poorly expressed	Partially expressed	Fairly clearly expressed	Clearly expressed and logical
Language and spelling	Poor	Minor mistakes	No mistakes	
Public appeal and neatness – overall impression	Not appealing. Untidy	Room for improvement	Appealing to most but lacks some important element/elements	Eye-catching. Very neat

A. **Rating Scale**

I rate the learner's table as: (tick in the block next to the selected face)

Very Good		
Good		
Average		
Poor		

B. **Feedback**

I give the learner Two stars for:

One thing that the learner can do to improve is:

Appendix V: Checklist and rating scale for peer assessment

Checklist and rating scale for the peer-assessment of learner's Model

Name of learner: ______________________________________ Grade 10

Name of assessor: ___________________________ Date of assessment: ________________

A. Rubric for marking learner's Model

Criterium	**4**	**3**	**2**	**1**
Correctness of model	The model is correct in all aspects	Essentially correct but lacks a minor detail	Most aspects of the model is correct but it has more than one detail lacking	The model is not correct or has major flaws
Size of model	The model is large enough to be used for whole class teaching	The model is large but some of the components are too small to be seen clearly at a distance of more than 1 m	The model is large but most of the components are too small to be seen clearly at a distance of more than 1 m	The model is far too small for whole class teaching
Use of colour	Colour is used in a systematic way to enhance learning	Good use of colour but lacks minor important elements to enhance learning	Colour is used but there is no system (haphazard)	No colour was used
Materials used	All materials used are waste products (very low cost)	Minor components are shop-bought (costs reasonably high)	About half the components are shop bought (costs reasonably high)	The whole model or most of it (more than 50%) was made of shop-bought materials (high costs)
Creativity	Impressive! Innovative! Shows a very high degree of creativity!	A very high degree of creativity but lacking minor elements	Some creativity is evident. Room for improvement	Does not show an acceptable level of creativity

B. **Rating Scale**

I rate the learner's table as: (tick in the block next to the selected face)

Very Good	☆ 	
Good		
Average		
Poor		

C. Feedback

I give the learner Two stars for:

One thing that the learner can do to improve is:

Appendix W: **Exercises**

Class exercise 1

Name of learner: ______________________________________ Grade 10

Name of assessor: _________________________ Date of assessment: ________________

Study the following examples of mixtures and classify them as homogeneous and heterogeneous:

Mixture	Homogeneous	Heterogeneous
1. Sponge cake		
2. Cup of coffee		
3. Muesli		
4. Scrambled eggs		
5. Wood		
6. A pizza		
7. Hair mousse		
8. Can of fizzy cold drink		
9. Cornflakes		
10. Stainless steel bowl		
11. Petrol		
12. Brass		
13. Clouds		
14. Two-stroke motor oil (petrol-oil mixture)		

An exercise taken from learners' Physical Sciences textbook by Kelner, 2010:124

UNIT 1 Classification of matter

Learner's Book pages 124–146

LO1: AS1; AS2; AS4; LO2: AS3; LO3: AS2; AS3

Activity 1: Investigating mixtures

Learner's Book page 129

1.

Homogenous mixtures	Solvent	Solute
Can of fizzy cooldrink	Liquid cooldrink	Carbon dioxide gas
Cornflakes	Corn	Additives such as colourants and flavourants
Stainless steel bowl	Iron	Carbon and titanium
Petrol	Decane	Octane and other hydrocarbons
Brass	Copper	Zinc
Clouds	Gas (air)	Liquid (water)
Two stroke motor oil	Petrol	Oil
Cup of coffee	Water	Solid coffee

Heterogenous mixtures	Main phase	Particle type mixed into phase
Sponge cake	Solid	Gas (air)
Muesli	Solid (Oats)	Solid (raisins etc.)
Scrambled eggs (gel)	Solid	Liquid (milk etc.)
Pizza	Solid (base)	Solid (topping – cheese, tomato etc.)
Hair mousse (foam)	Liquid	Gas
Wood	Cellulose (Carbon)	Minerals, plant sap etc.

2. The aim of this part of the activity is to make learners aware of the different forms of matter all around us. Encourage the learners to identify different types of homogenous (e.g. gas in liquid, solid in gas) and heterogeneous mixtures (e.g. aerosol, gel, foam) in their homes. What might be especially interesting is the sheer number of additives and flavourants in some products, especially foodstuffs. Prompt learners to think about the effects of these products on the environment and our bodies. They can find such information from a nearby pharmacy, the library or the Internet.

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Class exercise 2

Name of learner: ____ Grade 10

Name of assessor: _________________________ Date of assessment: ________________

1. What is the relative atomic mass for the following elements atoms?

a) ${}^{7}_{3}Li$
b) Br
c) Cu

2. Write down the notation ${}^{A}_{Z}X$ for the following elements atoms

a) Sodium
b) Potassium
c) Zinc
d) Nitrogen

3. Use the orbital box diagram to illustrate the following neutral element atom

a) Nitrogen
b) Chlorine
c) Oxygen

Exercise 3

Name of learner: ____ Grade 10

Name of assessor: ____________________________________ Date of assessment: ________________

Give the electron configuration or spectroscopic configuration of the following atoms:

a) Lithium
b) Nitrogen
c) Neon
d) Chlorine

Exercise 4

Name of learner: ____ Grade 10

Name of assessor: ____________________________ Date of assessment: ________________

Complete the table below:

Name of compound	Formula	Valency	Atoms in the compound
Carbon dioxide	CO_2		1 carbon atoms, 2 oxygen atoms
			1 oxygen atom, 2 hydrogen atoms
Ammonia			
	$CuSO_4$		
			1 calcium atom, 1 oxygen atom
Calcium hydroxide			
	NH_4NO_3		
Iron (III) chloride			

Appendix X: Homework activities for learners

Homework Activities

Homework Activity 1

Name of learner: ______________________________________ Grade 10

Name of assessor: __________________________ Date of assessment: ________________

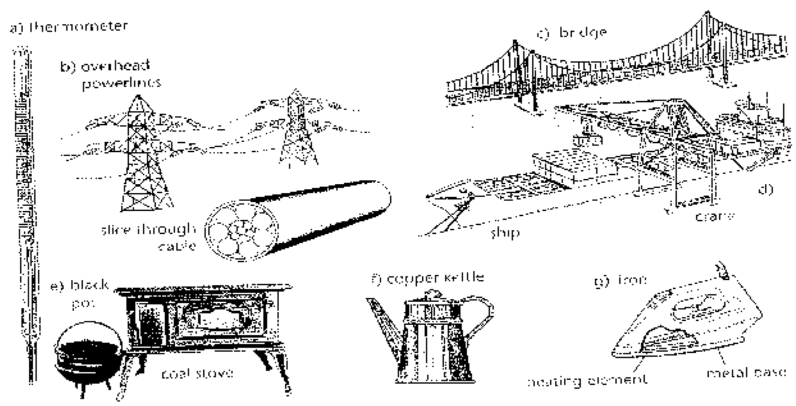
We use mixtures in our homes all the time. By law manufacturers are required to print the ingredients of the mixtures on the containers. Identify 6 mixtures in your home. Write down these substances – in what phase do they normally exist, are they safe to use, do they affect the environment adversely, why are they added to the product, etc? Use a selection of body cleaning and beautifying products, food products in tins, frozen or in packets, and household cleaners. Present your results in a table.

Homework Activity 2

Name of learner: ______________________________ **Grade 10**

Name of assessor: ______________________________ **Date of assessment:** ______________

For each picture explain how and where the properties of metals (as listed below) are applied.



1. Most metals are solids at room temperature.
2. Most metals have high melting points
3. Most metals are tough.
4. Most metals are strong.
5. We can hammer metals into shape.
6. We can pull metals out into thin wires.
7. Metals conduct heat.
8. Metals conduct electricity.

Homework activity taken from learner's Physical Sciences textbook by Kelder, 2008a:

Homework Activity 3

Name of learner: ____ Grade 10

Name of assessor: _________________________ Date of assessment: ________________

Answer the following question:

Aluminium shows many of the typical metallic properties. Make a list of these properties of aluminium. Explain three properties in terms of the electron-sea model.

Homework Activity 4

Name of learner: ____ Grade 10

Name of assessor: ___________________________ Date of assessment: ________________

Give the Lewis structure to illustrate the formation of ionic bonds and name the substances formed for:

a) sodium and oxygen;
b) potassium and chlorine;
c) aluminium and fluorine

APPENDIX Y: Library activities for learners (adopted from Kelder, 2008a:160)

Library Activity 1

The Periodic Table

The Periodic Table

In the 19th century, chemists noticed that groups of elements display similar properties. Many scientists tried to order the elements in some type of table and came up with a variety of tables. As many of the elements' atomic masses were known, one logical way was to organise these elements in a table according to their atomic masses.

The Russian chemist Dmitri Mendeleev was most successful. He found that both the physical and chemical properties of the elements vary periodically with increasing atomic mass. This is known as the **Periodic Law**. In 1869 he published a **Periodic Table** that included the 66 known elements. He left gaps in the table for elements that he didn't know. As more elements were discovered, it was easy to fit them into the empty spaces in the existing Periodic Table.

Dimitri Mendeleev

In 1913 Henry Moseley discovered the correlation between the atomic number of an element (the size of the positive charge) and its position on the Periodic Table. Today, elements in the Periodic Table are arranged in order of increasing atomic numbers.

MODULE 4: MATTER AND MATERIALS

The Periodic Table can be divided into horizontal rows (called periods) and vertical columns (called groups). We find a clear correlation between the elements of one group and their electron configurations. Let us examine only the electrons in the outer energy level. These electrons are called the valence electrons. For Groups I, II and VII we find the following electron configurations:

Group I	**Group II**	**Group VII**
Li: [He] $2s^1$	Be: [He] $2s^2$	F: [He] $2s^2\ 2p^5$
Na: [Ne] $3s^1$	Mg: [Ne] $3s^2$	Cl: [Ne] $3s^2\ 3p^5$
K: [Ar] $4s^1$	Ca: [Ar] $4s^2$	Br: [Ar] $4s^2\ 4p^5$

Notice that each member of the group has the same valence electron structure. The characteristics of an element in the group are therefore closely related to its valence electron structure.

Certain of the groups have special names:
Group I – alkali metals
Group II – alkali earth metals
Group VII – halogens
Group VIII or 0 – noble gases

As a group, the noble gases are chemically inert. That means that they do not react with any other atom. We see that they have completely filled outer energy levels. This condition represents great stability.

Ions form when an atom loses or gains one or more electrons. When an atom gains electrons, the resultant effect will be that the atoms now have more electrons than protons. The overall net charge on the atom will be negative. When an atom loses electrons, it will have fewer electrons than protons and the charge on the atom will be positive. Negative ions are called *anions*, and positive ions are called *cations*. When an element from Group I loses an electron, it will obtain the same electron structure as a noble gas. Elements from Group VII gain an electron to reach noble gas configuration.

For example:

Na: [Ne] $3s^1$	Na^+: [Ne]	F: [He] $2s^2\ 2p^5$	F^-: [He] $2s^2\ 2p^6$ = [Ne]
p^+: 11	p^+: 11	p^+: 9	p^+: 9
n^0: 12	n^0: 12	n^0: 10	n^0: 10
e^-: 11	e^-: 10	e^-: 9	e^-: 10

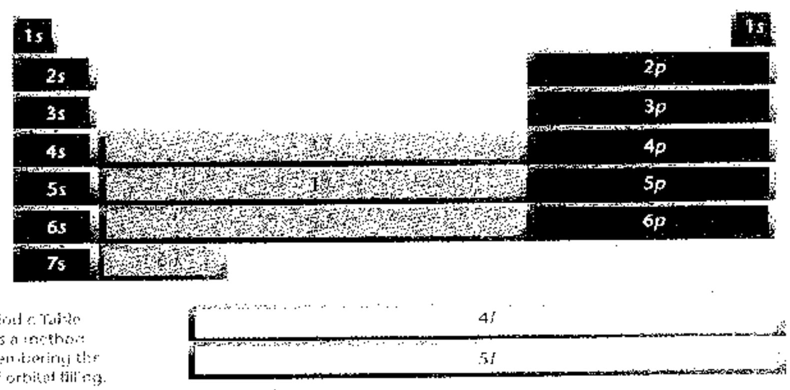
Note that both the sodium ion and the fluoride ion have the same number of electrons – they both obtained the stable neon noble gas electron configuration.

The horizontal periods correspond to the principle quantum number, *n* or energy level. For example, sodium is in the third period. Its first and second energy shells are filled, and its outer third energy shell contains one electron in a 3*s*-orbital. Fluorine is in the second period. It has a filled first energy shell and seven valence electrons in the outer second energy shell: two in the 2*s*-orbital and five in the 2*p*-orbitals. The number of electrons that an atom of an element gains, loses or shares to reach noble gas configuration is called its valency. Elements in Groups I, II, III and IV have a valency equal to the group number. Elements in Groups V, VI and VII have a valency equal to 8 minus the group number.

Group	I	II	III	IV	V	VI	VII
Valency	1	2	3	4	3	2	1

Filling the *d* and *f*-orbitals is not required in Grade 10. It is included to give a complete view of the table.

The Periodic Table can also be divided into four regions, or blocks of elements, according to the orbitals being filled. Groups I and II on the left side of the table form the *s*-block elements, because they result from filling an *s*-orbital; the Group III – VIII elements on the right side of the table are the *p*-block elements, because they result from filling *p* orbitals. The transition-metal *d*-block elements in the middle of the table result from filling the *d* orbitals. The lanthanide/actinide *f*-block elements result from filling the *f*-orbitals.



The Periodic Table provides a method for remembering the order of orbital filling.

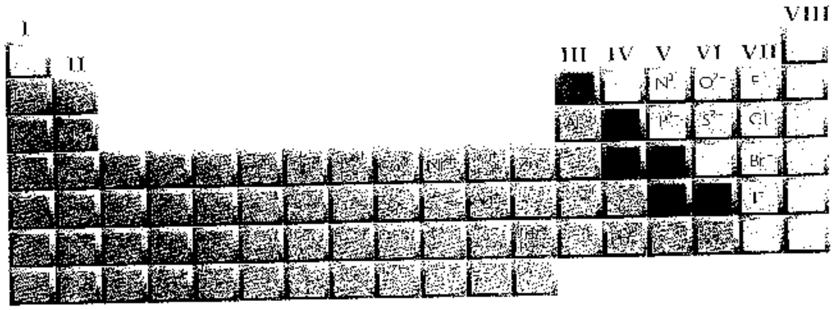
Library Activity 2

Study the theme "Naming the compounds" on pages 176 – 180 and "How to write the Chemical formulae" on pages 199 – 200 of your text Study and Master (Kelder, 2008).

Naming compounds

Compounds are named after their constituent elements. Ionic compounds are made up of anions and cations. The first part of the name is derived from the cation. With the important exceptions of the hydrogen ion (H^+) and the ammonium ion, NH_4^+, all cations are derived from metal atoms. Metal cations take their names from the elements. Some of the transition metals can lose different numbers of electrons, depending on the specific chemical reaction. To distinguish between the number of bonds in a compound, Roman numerals are used, for example, Cu^+ that has lost one electron is written as copper(I). Cu^{2+} that has lost two electrons is written as copper(II).

The second part of the name of an ionic compound comes from the anion. If the anion is monatomic (consists of one element only), the first part of the name is from the element name and '-ide' is added. For example, the ion of chlorine is called a chloride.



Two or more atoms can combine to form an ion that has a net positive or net negative charge. Polyatomic ions such as OH^- (hydroxide ion) and NH_4^+ (ammonium ion) are ions containing more than one atom.

Here are some lists of anionic names and the polyatomic ions.

	Anionic names
N^{3-}	Nitride
P^{3-}	Phosphide
O^{2-}	Oxide
S^{2-}	Sulphide
F^-	Fluoride
Cl^-	Chloride
Br^-	Bromide
I^-	Iodide

Valency	Polyatomic ions
1	Ammonium ion, NH_4^+
	Hydroxide ion, OH^-
	Nitrate ion, NO_3^-
	Nitrite ion, NO_2^-
	Chlorate ion, ClO_3^-
	Hydrogen sulphate ion, HSO_4^-
	Hydrogen carbonate ion, HCO_3^-
	Permanganate ion, MnO_4^-
2	Sulphate ion, SO_4^{2-}
	Sulphite ion, SO_3^{2-}
	Carbonate ion, CO_3^{2-}
3	Phosphate ion, PO_4^{3-}

Note the difference between an **-ide** (sulphide S^{2-}), an **-ite** (sulphite SO_3^{2-}) and an **-ate** (sulphate SO_4^{2-}).

The prefixes mono- (one), di- (two), tri- (three), tetra- (four), etc., are sometimes used to indicate the number of the same atoms in a compound, e.g. carbon monoxide for CO and carbon dioxide for CO_2.

To be able to write the chemical language of balanced equations, one needs to learn the words of the language. The following list contains many of the compounds that you will meet in chemistry.

Formula	Chemical name	Common name
Acids		
HCl	Hydrogen chloride	Hydrochloric acid
HNO_3	Hydrogen nitrate	Nitric acid
H_2SO_4	Hydrogen sulphate	Sulphuric acid
H_2SO_3	Hydrogen sulphite	Sulphurous acid
H_2CO_3	Hydrogen carbonate	Carbonic acid
Oxides		
CaO	Calcium oxide	Quicklime
K_2O	Potassium oxide	
CuO	Copper(II) oxide	
HgO	Mercury(II) oxide	
Li_2O	Lithium oxide	
PbO_2	Lead(IV) oxide	
MgO	Magnesium oxide	
Fe_3O_4	Magnetic iron oxide	Magnetite
Na_2O	Sodium oxide	
P_2O_5	Phosphorus pentoxide	
CO_2	Carbon dioxide	
SO_2	Sulphur dioxide	
H_2O	Hydrogen oxide	Water
CO	Carbon monoxide	
O_3	Ozone	
NO_2	Nitrogen dioxide	
Hydroxides		
$Ca(OH)_2$	Calcium hydroxide	Slaked lime
KOH	Potassium hydroxide	
$Mg(OH)_2$	Magnesium hydroxide	Milk of magnesia
$NaOH$	Sodium hydroxide	Caustic soda
Carbonates		
K_2CO_3	Potassium carbonate	Potash
$BaCO_3$	Barium carbonate	
$CaCO_3$	Calcium carbonate	Marble, limestone, chalk
$MgCO_3$	Magnesium carbonate	
Na_2CO_3	Sodium carbonate	Washing soda, soda ash
$NaHCO_3$	Sodium hydrogen carbonate	Baking soda, bicarbonate of soda

Formula	Chemical name	Common name
Nitrates		
$Ca(NO_3)_2$	Calcium nitrate	
KNO_3	Potassium nitrate	Saltpetre
$AgNO_3$	Silver nitrate	
$NaNO_3$	Sodium nitrate	Chile saltpetre
Sulphates		
$MgSO_4$	Magnesium sulphate	Epsom salts
$BaSO_4$	Barium sulphate	
$CuSO_4$	Copper(II) sulphate	
$CaSO_4$	Calcium sulphate	Gypsum
K_2SO_4	Potassium sulphate	
Na_2SO_4	Sodium sulphate	
$ZnSO_4$	Zinc sulphate	
$FeSO_4$	Iron(II) sulphate	
Chlorides		
$BaCl_2$	Barium chloride	
$NaCl$	Sodium chloride	Table salt
KCl	Potassium chloride	
$CuCl_2$	Copper(II) chloride	
$CuCl$	Copper(I) chloride	
$AgCl$	Silver chloride	
$CaCl_2$	Calcium chloride	
$FeCl_2$	Iron(II) chloride	
$FeCl_3$	Iron(III) chloride	
Bromides		
KBr	Potassium bromide	
$PbBr_2$	Lead(II) bromide	
$NaBr$	Sodium bromide	
$AgBr$	Silver bromide	
Iodides		
KI	Potassium iodide	
PbI_2	Lead(II) iodide	
NaI	Sodium iodide	
AgI	Silver iodide	

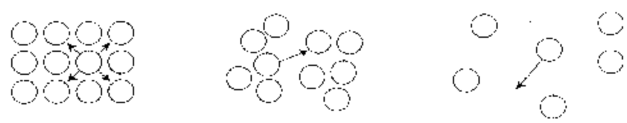
Organic compounds	Chemical name	Common name
CH_4	Methane	Natural gas
C_2H_6	Ethane	
C_2H_4	Ethene	Ethylene
C_2H_2	Ethyne	Acetylene
C_3H_8	Propane	
C_3H_6	Propene	Propylene
C_4H_{10}	Butane	
C_8H_{18}	Octane	Petrol
CH_4O	Methanol	Methyl alcohol
C_2H_6O	Ethanol	Ethyl alcohol
CH_2O_2	Methanoic acid	Formic acid
$C_2H_4O_2$	Ethanoic acid	Acetic acid (vinegar)

Physical state

All substances exist in one of three states: solid, liquid and gas. We use the state symbols (s), (ℓ) and (g) behind the symbol of the element or compound to show its phase, e.g. Cu(s) is in the solid phase and $H_2O(\ell)$ is a liquid.

The state in which a substance exists, depends on the following factors:

- the kinetic energy of its particles
- the intermolecular forces between the particles.



In ice, the water molecules are packed in a crystal lattice. The molecules vibrate about their fixed positions. In liquid water, the water molecules have more energy and can glide over each other. In water vapour, the water molecules have even more energy and can move about freely.

The kinetic energy of the particles determines how much they can move around. In a solid, the particles are packed in an orderly way. They have less kinetic energy than the particles of a gas, which can move around freely. **Intermolecular forces** hold particles together in the solid and liquid phases. If the kinetic energy of the particles is increased, they can overcome the intermolecular forces and change phase.

When the name of a compound is given, you can write its formula using these rules:

- Write down the symbols of any bonding elements and polyatomic ions. The symbol of the metal or positive ion goes on the left-hand side of the formula.
- Determine the valencies of the bonding elements and the polyatomic ions.
- Write down the valencies of the different elements and ions above the symbols.
- Work out how many atoms of each element are required for the total valency of the atoms of the first element to be equal to the total valency of the atoms of the second element.
- Remember that in a neutral compound the total negative charge must equal the total positive charge.
- The rules for both covalent and ionic compounds are the same.

Note: It is important to know the formulae and valencies of all the polyatomic ions, as well as the common names of substances. If you are unsure about these, revise the tables on pages 177–180 of *Matter and Materials*.

Examples: Writing chemical formulae for compounds

1. **Carbon dioxide**
   - valency of carbon = 4
   - valency of oxygen = 2
   - $\overset{4}{C} \quad \overset{2}{O}$
   - 2 atoms of oxygen are required to make a neutral molecule.

   The formula is CO_2

   Carbon dioxide is a covalently bonded molecule. The atoms share the electrons and do not form ions. The valencies are neutral.

2. **Sodium oxide**
   - valency of sodium = +1
   - valency of oxygen = −2
   - $\overset{+1}{Na}\ \overset{-2}{O}$
   - 2 ions of sodium are required to balance the −2 of oxygen in order to give a neutral substance.

   The formula is Na_2O

   Sodium oxide is an ionic compound. The sodium ion will have a charge of +1 and therefore a positive sign is added to its valency. The same applies for the oxide ion.

3. **Iron(III) chloride**
   - valency of iron = +3
     valency of chlorine = −1
   - $\overset{+3}{Fe}\ \overset{-1}{Cl}$
   - 3 chloride ions are required to balance the +3 of the Fe^{3+} ion.

   The formula is $FeCl_3$

   The (III) in iron(III) chloride indicates that the valency of the iron ion is +3. Iron can also form a Fe^{2+} ion.

4. **Ammonium sulphate**
   - valency of ammonium = +1
   - valency of sulphate = −2
   - $\overset{+1}{NH_4}\ \overset{-2}{SO_4}$
   - 2 ammonium ions are required to balance the −2 of the sulphate ion.

   The formula is $(NH_4)_2SO_4$

   Note: Brackets must be placed around the polyatomic ion if more than one ion is needed in the compound.

5. **Aluminium sulphate**
   - valency of aluminium = +3
   - valency of sulphate = −2
   - $\overset{+3}{Al}\ \overset{-2}{SO_4}$
   - The smallest common denominator of 2 and 3 is 6. We need a total positive charge of +6 and a total negative charge of −6. 2 Al^{3+} ions are required for a total positive charge of $2 \times (+3) = +6$. 3 SO_4^{2-} ions are required for a total negative charge of $3 \times (-2) = -6$. The overall charge on the compound is 0.

   The formula is $Al_2(SO_4)_3$