education

Department of Education
REPUBLIC OF SOUTH AFRICA

National Curriculum Statement
Grades 10-12
(General)

PHYSICAL SCIENCES

Department of Education

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HOW TO USE THIS BOOK

This document is a policy document divided into four chapters. It is important for the reader to read and integrate information from the different sections in the document. The content of each chapter is described below.

Chapter 1 - Introducing the National Curriculum Statement

This chapter describes the principles and the design features of the National Curriculum Statement Grades 10 – 12 (General). It provides an introduction to the curriculum for the reader.

Chapter 2 - Introducing the Subject

This chapter describes the definition, purpose, scope, career links and Learning Outcomes of the subject. It provides an orientation to the Subject Statement.

Chapter 3 - Learning Outcomes, Assessment Standards, Content and Contexts

This chapter contains the Assessment Standards for each Learning Outcome, as well as content and contexts for the subject. The Assessment Standards are arranged to assist the reader to see the intended progression from Grade 10 to Grade12. The Assessment Standards are consequently laid out in double-page spreads. At the end of the chapter is the proposed content and contexts to teach, learn and attain Assessment Standards.

Chapter 4 – Assessment

This chapter deals with the generic approach to assessment being suggested by the National Curriculum Statement. At the end of the chapter is a table of subject-specific competence descriptions. Codes, scales and competence descriptions are provided for each grade. The competence descriptions are arranged to demonstrate progression from Grade 10 to Grade 12.

Symbols

The following symbols are used to identify Learning Outcomes, Assessment Standards, grades, codes, scales, competence description, and content and contexts.

= Learning Outcome

= Assessment Standard

= Grade

= Code

= Scale

= Competence Description

= Content and Contexts

CONTENTS

ACRONYMS

2D	Two dimensional
3D	Three dimensional
AC	Alternating Current
AIDS	Acquired Immune Deficiency Syndrome
CASS	Continuous Assessment
CO	Critical Outcome
DC	Direct Current
DO	Developmental Outcome
EM	Electromagnetic
FET	Further Education and Training
GET	General Education and Training
HET	Higher Education and Training
HIV	Human Immunodeficiency Virus
IKS	Indigenous Knowledge Systems
LED	Light-Emitting Diode
NCS	National Curriculum Statement
NQF	National Qualifications Framework
P.D.	Potential Difference
OBE	Outcomes-based Education
SALT	Southern African Large Telescope
SAQA	South African Qualifications Authority
SI	Systèrme International

CHAPTER 1

INTRODUCING THE NATIONAL CURRICULUM STATEMENT

The adoption of the Constitution of the Republic of South Africa (Act 108 of 1996) provided a basis for curriculum transformation and development in South Africa. The Preamble states that the aims of the Constitution are to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;
- improve the quality of life of all citizens and free the potential of each person;
- lay 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
- build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations.

The Constitution further states that 'everyone has the right … to further education which the State, through reasonable measures, must make progressively available and accessible'.

The National Curriculum Statement Grades 10 – 12 (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.

PRINCIPLES

The National Curriculum Statement Grades 10 – 12 (General) 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.

Social transformation

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 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 qualifications.

Outcomes-based education

Outcomes-based education (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 to be achieved by the end of the education process. OBE encourages a learner-centred and activity-based approach to education. The National Curriculum Statement builds its Learning Outcomes for Grades 10 – 12 on the Critical and Developmental Outcomes that were inspired by the Constitution and developed through a democratic process.

The Critical Outcomes require learners to be able to:

- identify and solve problems and make decisions using critical and creative thinking;
- work effectively with others as members of a team, group, organisation and community;
- organise and manage themselves and their activities responsibly and effectively;
- collect, analyse, organise and critically evaluate information;
- communicate effectively using visual, symbolic and/or language skills in various modes;
- use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
- demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

The Developmental Outcomes require learners to be able to:

- reflect on and explore a variety of strategies to learn more effectively;
- participate as responsible citizens in the life of local, national and global communities;
- be culturally and aesthetically sensitive across a range of social contexts;
- explore education and career opportunities; and
- develop entrepreneurial opportunities.

High knowledge and high skills

The National Curriculum Statement Grades 10 – 12 (General) aims to develop a high level of knowledge and skills in learners. It sets up high expectations of what all South African learners can achieve. Social justice requires the empowerment of those sections of the population previously disempowered by the lack of knowledge and 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.

Integration and applied competence

Integration is achieved within and across subjects and fields of learning. The integration of knowledge and skills across subjects and terrains of practice is crucial for achieving applied competence as defined in the National Qualifications Framework. Applied competence aims at integrating three discrete competences – namely, practical, foundational and reflective competences. In adopting integration and applied competence, the National Curriculum Statement Grades 10 – 12 (General) seeks to promote an integrated learning of theory, practice and reflection.

Progression

Progression refers to the process of developing more advanced and complex knowledge and skills. The Subject Statements show progression from one grade to another. Each Learning Outcome is followed by an explicit statement of what level of performance is expected for the outcome. Assessment Standards are arranged in a format that shows an increased level of expected performance per grade. The content and context of each grade will also show progression from simple to complex.

Articulation and portability

Articulation refers to the relationship between qualifications in different National Qualifications Framework levels or bands in ways that promote access from one qualification to another. This is especially important for qualifications falling within the same learning pathway. Given that the Further Education and Training band is nested between the General Education and Training and the Higher Education bands, it is vital that the Further Education and Training Certificate (General) articulates with the General Education and Training Certificate and with qualifications in similar learning pathways of Higher Education. In order to achieve this articulation, the development of each Subject Statement included a close scrutiny of the exit level expectations in the General Education and Training Learning Areas, and of the learning assumed to be in place at the entrance levels of cognate disciplines in Higher Education.

Portability 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 National Qualifications Framework band. For purposes of enhancing the portability of subjects obtained in Grades 10 – 12, various mechanisms have been explored, for example, regarding a subject as a 20-credit unit standard. Subjects contained in the National Curriculum Statement Grades 10 – 12 (General) compare with appropriate unit standards registered on the National Qualifications Framework.

Human rights, inclusivity, environmental and social justice

The National Curriculum Statement Grades 10 – 12 (General) seeks to promote human rights, inclusitivity, environmental and social justice. All newly-developed Subject Statements are infused with the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa. In particular, the National Curriculum Statement Grades 10 – 12 (General) is sensitive to issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors.

The National Curriculum Statement Grades 10 – 12 (General) adopts an inclusive approach by specifying minimum requirements for all learners. It acknowledges that all learners should be able to develop to their full potential provided they receive the necessary support. The intellectual, social, emotional, spiritual and physical needs of learners will be addressed through the design and development of appropriate Learning Programmes and through the use of appropriate assessment instruments.

Valuing indigenous knowledge systems

In the 1960s, the theory of multiple-intelligences forced educationists to recognise that there were many ways of processing information to make sense of the world, and that, if one were to define intelligence anew, one would have to take these different approaches into account. Up until then the Western world had only valued logical, mathematical and specific linguistic abilities, and rated people as 'intelligent' only if they were adept in these ways. Now people recognise the wide diversity of knowledge systems through which people make sense of and attach meaning to the world in which they live. 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. The National Curriculum Statement Grades 10 – 12 (General) has infused indigenous knowledge systems into the Subject Statements. It acknowledges the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution. As many different perspectives as possible have been included to assist problem solving in all fields.

Credibility, quality and efficiency

The National Curriculum Statement Grades 10 – 12 (General) aims 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. Quality assurance is to be regulated by the requirements of the South African Qualifications Authority Act (Act 58 of 1995), the Education and Training Quality Assurance Regulations, and the General and Further Education and Training Quality Assurance Act (Act 58 of 2001).

THE KIND OF LEARNER THAT IS ENVISAGED

Of vital importance to our development as people are the values that give meaning to our personal spiritual and intellectual journeys. *The Manifesto on Values, Education and Democracy* (Department of Education, 2001:9-10) states the following about education and values:

> *Values and morality give meaning to our individual and social relationships. They are the common currencies that help make life more meaningful than might otherwise have been. An education system does not exist to simply serve a market, important as that may be for economic growth and material prosperity. Its primary purpose must be to enrich the individual and, by extension, the broader society.*

The kind of learner that is envisaged is one who will be imbued with the values and act in the interests of a society based on respect for democracy, equality, human dignity and social justice as promoted in the Constitution.

The learner emerging from the Further Education and Training band must also demonstrate achievement of the Critical and Developmental Outcomes listed earlier in this document. Subjects in the Fundamental Learning Component collectively promote the achievement of the Critical and Developmental Outcomes, while specific subjects in the Core and Elective Components individually promote the achievement of particular Critical and Developmental Outcomes.

In addition to the above, learners emerging from the Further Education and Training band must:

- have access to, and succeed in, lifelong education and training of good quality;
- demonstrate an ability to think logically and analytically, as well as holistically and laterally; and
- be able to transfer skills from familiar to unfamiliar situations.

THE KIND OF TEACHER THAT IS ENVISAGED

All teachers and other educators are key contributors to the transformation of education in South Africa. The National Curriculum Statement Grades 10 – 12 (General) visualises teachers who are qualified, competent, dedicated and caring. They will be able to fulfil the various roles outlined in the Norms and Standards for Educators. These include being mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors, and subject specialists.

STRUCTURE AND DESIGN FEATURES

Structure of the National Curriculum Statement

The National Curriculum Statement Grades 10 – 12 (General) consists of an Overview Document, the Qualifications and Assessment Policy Framework, and the Subject Statements.

The subjects in the National Curriculum Statement Grades 10 – 12 (General) are categorised into Learning Fields.

What is a Learning Field?

A Learning Field is a category that serves as a home for cognate subjects, and that facilitates the formulation of rules of combination for the Further Education and Training Certificate (General). The demarcations of the Learning Fields for Grades 10 – 12 took cognisance of articulation with the General Education and Training and Higher Education bands, as well as with classification schemes in other countries.

Although the development of the National Curriculum Statement Grades 10 – 12 (General) has taken the twelve National Qualifications Framework organising fields as its point of departure, it should be emphasised that those organising fields are not necessarily Learning Fields or 'knowledge' fields, but rather are linked to occupational categories.

The following subject groupings were demarcated into Learning Fields to help with learner subject combinations:

- Languages (Fundamentals);
- Arts and Culture;
- Business, Commerce, Management and Service Studies;
- Manufacturing, Engineering and Technology;
- Human and Social Sciences and Languages; and
- Physical, Mathematical, Computer, Life and Agricultural Sciences.

What is a subject?

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 like the National Curriculum Statement Grades 10 – 12 (General), subject boundaries are blurred. Knowledge integrates theory, skills and values. Subjects are viewed as dynamic, always responding to new and diverse knowledge, including knowledge that traditionally has been excluded from the formal curriculum.

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. Learning Outcomes are defined in broad terms and are flexible, making allowances for the inclusion of local inputs.

What is a Learning Outcome?

A Learning Outcome is a statement of an intended result of learning and teaching. It describes knowledge, skills and values that learners should acquire by the end of the Further Education and Training band.

What is an Assessment Standard?

Assessment Standards are criteria that collectively describe what a learner should know and be able to demonstrate at a specific grade. They embody the knowledge, skills and values required to achieve the Learning Outcomes. Assessment Standards within each Learning Outcome collectively show how conceptual progression occurs from grade to grade.

Contents of Subject Statements

Each Subject Statement consists of four chapters and a glossary:

- *Chapter 1, Introducing the National Curriculum Statement:* This generic chapter introduces the National Curriculum Statement Grades 10 – 12 (General).
- *Chapter 2, Introducing the Subject:* This chapter introduces the key features of the subject. It consists of a definition of the subject, its purpose, scope, educational and career links, and Learning Outcomes.
- *Chapter 3, Learning Outcomes, Assessment Standards, Content and Contexts:* This chapter contains Learning Outcomes with their associated Assessment Standards, as well as content and contexts for attaining the Assessment Standards.
- *Chapter 4, Assessment:* This chapter outlines principles for assessment and makes suggestions for recording and reporting on assessment. It also lists subject-specific competence descriptions.
- *Glossary:* Where appropriate, a list of selected general and subject-specific terms are briefly defined.

LEARNING PROGRAMME GUIDELINES

A Learning Programme specifies the scope of learning and assessment for the three grades in the Further Education and Training band. It is the plan that ensures that learners achieve the Learning Outcomes as prescribed by the Assessment Standards for a particular grade. The Learning Programme Guidelines assist teachers and other Learning Programme developers to plan and design quality learning, teaching and assessment programmes.

CHAPTER 2
PHYSICAL SCIENCES

DEFINITION

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 responsibly.

PURPOSE

The Physical Sciences plays an increasingly important role in the lives of all South Africans due to its influence on scientific and technological development, which underpins our country's economic growth and the social well-being of our community. It underpins many of the technologies that we take for granted – the homes we live in, the food we eat, the clothes we wear, the materials we use, medical diagnosis and treatment, computers and other information technologies. There is every reason to expect that the knowledge, skills and values people learn in the Physical Sciences will make even more of an impact on our lives as we move into the twenty-first century.

The application of Physical Sciences knowledge has a profound impact on world-wide issues and events — economic, environmental, ethical, political, social and technological.

An understanding of scientific perspectives will enhance participation by citizens when they are called upon to exercise their rights in deciding on and responding to the directions of science and technology. The subject fosters an ethical and responsible attitude towards learning, constructing and applying Physical Sciences, and accommodates reflection and debate on its findings, models and theories.

South Africa has a legacy in which the poor quality and/or lack of education in certain sectors resulted in limited access to scientific knowledge and the devaluing of indigenous scientific knowledge. Therefore, the curriculum of Physical Sciences must ensure increased access to scientific knowledge and scientific literacy.

The study of Physical Sciences is aimed at correcting some of these historical limitations by contributing towards the holistic development of learners in the following ways:

- giving learners the ability to work in scientific ways or to apply scientific principles which have proved effective in understanding and dealing with the natural and physical world in which they live;
- stimulating their curiosity, deepening their interest in the natural and physical world in which they live, and guiding them to reflect on the universe;
- developing insights and respect for different scientific perspectives and a sensitivity to cultural beliefs,

prejudices and practices in society (this aspect should also include the mobilising of African indigenous scientific knowledge and practices, particularly as these relate to solving social and environmental challenges in Africa);

- developing useful skills and attitudes that will prepare learners for various situations in life, such as self-employment and entrepreneurial ventures; and
- 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.

SCOPE

The subject Physical Sciences prepares learners for future learning, specialist learning, employment, citizenship, holistic development, socio-economic development and environmental management by developing competences in the following three focus areas:

- scientific inquiry and problem solving in a variety of scientific, technological, socio-economic and environmental contexts;
- the construction and application of scientific and technological knowledge; and
- the nature of science and its relationship to technology, society and the environment.

Scientific inquiry and problem-solving skills

The skills and processes which learners use and develop in the study of Physical Sciences are similar to those used by scientists at work. They build on skills already developed in the General Education and Training band. These are the tools that learners need in order to understand the working of the world. The development of these skills and processes allows learners to solve problems, think critically, make decisions, find answers, and satisfy their curiosity. These skills are the focus of all science learning and assessment activities in classrooms, but cannot be developed in isolation. They are best developed within the context of an expanding framework of scientific knowledge. In addition, learners must be able to use these skills and processes while working with others to achieve common goals. This will require broadening access to appropriate and sufficient resources, including adequate time and space for effective inquiry-based science teaching and learning. It is within this context that this subject also focuses on the construction and application of scientific knowledge.

Construction and application of scientific and technological knowledge

Knowledge in the Physical Sciences is organised around six core knowledge areas. These main knowledge areas are broad descriptors and ensure proper planning and clustering of concepts, skills and values to support achievement of learning outcomes. They are organised in such a way that they can be used to achieve all the Learning Outcomes of the Physical Sciences. This approach allows learners to learn the prescribed core knowledge and concepts by the end of Grade 12, but with increasing depth and breadth. More examples are given under the Assessment Standards. The core concepts to be learned are included and in the section on 'Content and Contexts for the Attainment of Assessment Standards' in Chapter 3.

The six core knowledge areas have the following foci:

- two with a chemistry focus – Systems; Change:
- three with a physics focus – Mechanics; Waves, Sound and Light; Electricity and Magnetism; and
- one with an integrated focus – Matter and Materials.

These six knowledge areas and the percentage of annual time in the curriculum to be devoted to them are listed in Table 2.1.

Table 2.1 The six knowledge areas for the Physical Sciences

Knowledge area	Type	Time
Matter and Materials	Integrated	25.00%
Systems	Chemistry	18.75%
Change	Chemistry	18.75%
Mechanics	Physics	12.50%
Waves, sound and light	Physics	12.50%
Electricity & magnetism	Physics	12.50%

Science, society and environmental issues

The main knowledge areas specified above are used as contexts to develop competences in learners to enable them to understand the relationships between science and technology, society and environment. It is important, therefore, for learners in the Physical Sciences to understand:

- the scientific enterprise and, in particular, how scientific knowledge develops;
- that scientific knowledge is in principle tentative and subject to change as new evidence becomes available;
- that knowledge is contested and accepted, and depends on social, religious and political factors;
- that other systems of knowledge, such as indigenous knowledge systems, should also be considered;
- that the explanatory power and limitations of scientific models and theories need to be evaluated;
- how science relates to their everyday lives, to the environment and to a sustainable future; and
- the importance of scientific and technological advancements and to evaluate their impact on human lives.

EDUCATIONAL AND CAREER LINKS

The study of Physical Sciences draws upon and builds on the knowledge and understanding, skills, and values and attitudes developed in the study of Natural Sciences in the General Education and Training band. The study of the Natural Sciences focuses on four knowledge areas – Life and Living, Earth and Beyond, Matter and Material, and Energy and Change. The learners in the General Education and Training band are encouraged to use concepts in a variety of contexts including scientific investigations, constructing science knowledge, and science, society and the environment.

In the Further Education and Training band, a number of science subjects build on the foundation laid by the Natural Sciences. The Physical Sciences is one of these subjects. It builds on the Earth and Beyond, Matter and Material, and Energy and Change knowledge areas of the Natural Sciences. The Learning Outcomes for the Physical Sciences and Life Sciences subjects ensure continuity by linking directly with the General Education and Training Learning Outcomes.

The same organising principles and design features have been used in this subject as in the National Curriculum Statement Grades R-9 (Schools). The nature of science forms the basis from which learning outcomes have been developed. This allows for the smooth progression of learners. The Physical Sciences curriculum will not only deepen the knowledge base laid in the General Education and Training band; it will also provide learners with deeper general knowledge, specialised knowledge and skills. This will enable them to enter Higher Education and Training or to follow various career pathways, and to take their place in society as informed and responsible citizens.

Science process skills and the creative mind developed through the problem-solving activities also allow learners to follow career paths other than those directly related to science; for example, higher education courses such as Computer Sciences, Mathematics and health-related fields.

Thus, learners who have studied Physical Sciences will have access to:

- academic courses at institutions such as universities and technikons to study science and science-related programmes, which can lead to science-based studies (e.g. sciences, engineering, bio-technology and environmental degrees);
- professional career paths related to applied science courses and engineering (e.g. science teachers, nurses, medical doctors, veterinarians, radiographers, dentists, chemical engineers, mechanical engineers and pharmacists); and
- vocational career paths (e.g. technicians, technologists and beauty therapists).

LEARNING OUTCOMES

The three Learning Outcomes of the Physical Sciences are aligned to the three focus areas identified in the section above on ‘Scope’. Thus, they aim to develop the abilities of:

- doing (skills), applying and constructing knowledge (Learning Outcome 1);
- knowing (knowledge) (Learning Outcome 2); and
- being and becoming (values and attitudes) (Learning Outcome 3).

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

The thrust of this Learning Outcome is on the doing aspects and the process skills required for scientific inquiry and problem solving. Learners’ understanding of the world will be informed by the use of scientific inquiry skills like planning, observing and gathering information, comprehension, synthesising, generalising, hypothesising and communicating results and conclusions. In addition to investigation of natural phenomena, information will be used in problem solving. Problem solving is central to the teaching and learning of Physical Sciences. Higher-order thinking and problem-solving skills are required to meet the demands of the labour market and for active citizenship within communities with increasingly complex technological, environmental and societal problems. Problem solving involves identification and analysis of the problem at hand, and the design of procedures to reach solutions. These skills find application in all spheres of life and in all contexts.

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.

This Learning Outcome concerns itself with the knowledge of the universe, the world and the environment. Technology, as understood in this outcome, incorporates ways and means of using the physical sciences in the service of humankind, thus enhancing and improving the quality of human life. Underlying this Learning Outcome is the notion of constructing, understanding and applying knowledge in socially, technologically and environmentally responsible ways. The content (facts, concepts, principles, theories, models and laws) and skills studied in Physical Sciences helps learners to gain a better understanding of the world they live in, and to explain physical and chemical phenomena. The context in which learning occurs is important – it establishes the purposes for the knowledge, and the ideas and experiences to which the knowledge relates. Progression in this Learning Outcome is ensured through increasing difficulty of concepts and the nature of contexts.

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.

It is important for learners to understand the scientific enterprise and, in particular, how scientific knowledge develops. Modern science is based on traditions of thought that came together in Europe about 500 years ago. People from other cultures have developed alternative ways of thinking resulting in different knowledge systems, which are increasingly interactive with Mainstream science. Scientific knowledge is tentative and subject to change as new evidence becomes available and new problems are addressed. The study of historical, environmental and cultural perspectives on science highlights how it changes over time, depending not only on experience but also on social, religious and political factors. Learners at the Further Education and Training stage evaluate the limitations of the explanatory power of scientific models and of different theories to explain phenomena. It is also necessary to help learners make informed decisions and enable them to have a broader understanding of how science relates to their everyday lives, to the environment and to a sustainable future. Acknowledging this interrelationship between science, society and the environment will contribute to active debates and responsible decision making on issues related to technological development, environmental management, lifestyle choices, economics, human health, and social and human development. Scientific and technological advancements affect all aspects of our lives, and it is important for learners to evaluate that impact.

Relationship to Critical and Developmental Outcomes

The three Learning Outcomes for the Physical Sciences were designed down from the Critical and Developmental Outcomes. For the convenience of the reader, the seven Critical Outcomes and the five Developmental Outcomes discussed in Chapter 1 are reproduced here:

Critical Outcomes

The Critical Outcomes require learners to be able to:

- identify and solve problems and make decisions using critical and creative thinking (CO1);
- work effectively with others as members of a team, group, organisation and community (CO2);
- organise and manage themselves and their activities responsibly and effectively (CO3);
- collect, analyse, organise and critically evaluate information (CO4);
- communicate effectively using visual, symbolic and/or language skills in various modes (CO5);
- use science and technology effectively and critically showing responsibility towards the environment and health of others (CO6); and
- demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation (CO7).

Developmental Outcomes

The Developmental Outcomes require learners to be able to:

- reflect on and explore a variety of strategies to learn more effectively (DO1);
- participate as responsible citizens in the life of local, national and global communities (DO2);
- be culturally and aesthetically sensitive across a range of social contexts (DO3);
- explore education and career opportunities (DO4); and
- develop entrepreneurial opportunities (DO5).

The Learning Outcomes for Physical Sciences and the Critical and Developmental Outcomes relate to each other as follows:

- *Learning Outcome 1* represents Critical Outcomes 1 to 5 by focusing on process skills, scientific reasoning, critical thinking and problem solving, and on working effectively with others and individually. The activities to build Learning Outcome 1 also reflect Developmental Outcome 1.
- *Learning Outcome 2* represents Critical Outcomes 4 and 5 by focusing on constructing, understanding and applying scientific knowledge. The activities to build Learning Outcome 2 also reflect Developmental Outcomes 1 and 4.
- *Learning Outcome 3* represents Critical Outcomes 1, 3, 4, 6 and 7 whereby learners show the ability to see the world as a set of related systems by focusing learners' understanding of the interrelationship between science, technology, society, ethics and the environment. Activities required to build Learning Outcome 4 also reflect Developmental Outcomes 2 and 3.

Weightings of the Learning Outcomes

The three Learning Outcomes and the Assessment Standards are of equal importance. This implies that the Learning Outcomes require the same prominence in terms of teaching and assessment time. Therefore, it is proposed that Learning Outcomes should not be dealt with separately in the classroom. The planning of learning units must reflect the integration of the different Learning Outcomes. The Learning Programme Guidelines provide guidance on how to plan learning units that demonstrate integration of the Learning Outcomes.

CHAPTER 3

LEARNING OUTCOMES, ASSESSMENT STANDARDS, CONTENT AND CONTEXTS

The Physical Sciences Subject Statement addresses Critical and Developmental Outcomes through three Learning Outcomes. In this chapter we introduce the Assessment Standards which describe the ways in which learners demonstrate the achievement of the Learning Outcomes. The table below shows the thrusts of the Assessment Standards in the three Learning Outcomes.

Table 3.1 Thrust of the Assessment Standards for each Learning Outcome

	Learning Outcome 1: Practical Scientific Inquiry and Problem-solving Skills	**Learning Outcome 2: Constructing and Applying Scientific Knowledge**	**Learning Outcome 3: The Nature of Science and its Relationship to Technology, Society and the Environment**
Thrusts of the Assessment Standards	Conducting an investigation.	Recalling and stating specified concepts.	Evaluating knowledge claims and science's inability to stand in isolation from other fields.
	Interpreting data to draw conclusions.	Indicating and explaining relationships.	Evaluating the impact of science on human development.
	Solving problems		
	Communicating and presenting information and scientific arguments.	Applying scientific knowledge.	Evaluating science's impact on the environment and sustainable development.

The Assessment Standards for the thrusts included in the above table appear in the following pages. The thrusts are included in the shaded bar running horizontally above the actual Assessment Standards, which spell out statements of achievement. The Assessment Standards are arranged from left to right (Grade 10 to Grade 12), in increasing levels of complexity. Examples of how the Assessment Standards can be attained are also included, preceded by the phrase '*Attainment is evident when the learner, for example,*'. It should be noted that these are possible examples that may change depending on the context in which the main knowledge areas are dealt with. The examples are drawn from the list of Core Knowledge and Concepts which appears at the end of

Grade 10

Learning Outcome 1

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.

Progression will be reflected in the differentiation of the problem situation, as it moves from routine problem-solving skills to high order problem-solving skills. The Assessment Standards build on and link with the Assessment Standards for Grades 7-9 as provided in the Revised National Curriculum Statement Grades R-9 (Schools) to reflect on-going progression. The examples provided illustrate this increasing complexity of problem-solving skills but do not necessarily show increasing complexity of concepts used.

Assessment Standards

CONDUCTING AN INVESTIGATION

We know this when the learner is able to:

- Plan and conduct a scientific investigation to collect data systematically with regard to accuracy, reliability and the need to control one variable.

Attainment is evident when the learner, for example,

- plans and conducts an experiment to determine the speed of waves in a medium;
- plans and conducts an experiment to measure property of some materials.

INTERPRETING DATA TO DRAW CONCLUSIONS

- Seek patterns and trends in the information collected and link it to existing scientific knowledge to help draw conclusions.

Attainment is evident when the learner, for example,

- analyses and interprets the properties of waves during their transmission in a medium, and from one medium to another, to draw conclusions;
- compares the properties of some materials and interprets .

Grade 11

Assessment Standards

CONDUCTING AN INVESTIGATION

We know this when the learner is able to:

- Plan and conduct a scientific investigation to collect data systematically with regard to accuracy, reliability and the need to control variables.

Attainment is evident when the learner, for example,

- determines through experiments, properties of solutions;
- investigates the qualitative effect of changing resistance on the current in a circuit and the quantitative relationship between power, voltage and current with reference to all variables.

INTERPRETING DATA TO DRAW CONCLUSIONS

- Seek patterns and trends, represent them in different forms to draw conclusions, and formulate simple generalisations.

Attainment is evident when the learner , for example,

- uses graphical methods to indicate the relationship between resistance and the factors affecting resistance;
- establishes the relative strength of acids by measuring conductivity.

Grade 12

Assessment Standards

CONDUCTING AN INVESTIGATION

We know this when the learner is able to:

- Design, plan and conduct a scientific inquiry to collect data systematically with regard to accuracy, reliability and the need to control variables.

Attainment is evident when the learner, for example,

- designs and carries out an experiment to identify specific variables that affect motion (e.g. an experiment to verify Newton's second law of motion);
- uses experimentation to determine some of the properties of organic compounds;
- synthesises a common organic compound such as soap.

INTERPRETING DATA TO DRAW CONCLUSIONS

- Seek patterns and trends, represent them in different forms, explain the trends, use scientific reasoning to draw and evaluate conclusions, and formulate generalisations.

Attainment is evident when the learner, for example,

- interprets patterns and trends in data in order to analyse and explain the motion of objects;
- interprets the information gathered on the use of electrical energy, to identify patterns and trends of power usage during all seasons, day and night, and formulates strategies to conserve energy.

Grade 10

Learning Outcome 1 Continued

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.

Progression will be reflected in the differentiation of the problem situation, as it moves from routine problem-solving skills to high order problem-solving skills. The Assessment Standards build on and link with the Assessment Standards for Grades 7-9 as provided in the Revised National Curriculum Statement Grades R-9 (Schools) to reflect on-going progression. The examples provided illustrate this increasing complexity of problem-solving skills but do not necessarily show increasing complexity of concepts used.

Assessment Standards

SOLVING PROBLEMS

We know this when the learner is able to:

- Apply given steps in a problem-solving strategy to solve standard exercises.

Attainment is evident when the learner, for example,

- draws a diagram, identifies what is known, selects a suitable equation, solves the equation and checks that the answer makes sense for a standard kinematics exercise. Apply known problem-solving strategies to solve multi-step problems.

Grade 11

Assessment Standards

SOLVING PROBLEMS

We know this when the learner is able to:

- Apply known problem-solving strategies to solve multi-step problems.

Attainment is evident when the learner, for example,

- uses kinematics to calculate the acceleration of an object being pulled up a slope and then uses the calculated value of acceleration to determine the force with which the object is being pulled. Select and use appropriate problem-solving strategies to solve novel (unseen) problems.

Grade 12

Assessment Standards

SOLVING PROBLEMS

We know this when the learner is able to:

- Select and use appropriate problem-solving strategies to solve (unseen) problems.

Attainment is evident when the learner, for example,

- decides what information is needed and what steps must be followed to determine how far away a satellite is, using a laser.

Grade 10

Learning Outcome 1 Continued

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.

Progression will be reflected in the differentiation of the problem situation, as it moves from routine problem-solving skills to high order problem-solving skills. The Assessment Standards build on and link with the Assessment Standards for Grades 7-9 as provided in the Revised National Curriculum Statement Grades R-9 (Schools) to reflect on-going progression. The examples provided illustrate this increasing complexity of problem-solving skills but do not necessarily show increasing complexity of concepts used.

Assessment Standards

COMMUNICATING AND PRESENTING INFORMATION AND SCIENTIFIC ARGUMENTS

We know this when the learner is able to:

- Communicate information and conclusions with clarity and precision.

Attainment is evident when the learner, for example,

- selects and uses appropriate vocabulary, SI units, and numeric and linguistic modes of representation to communicate scientific ideas and plans related to experimental procedures;
- reports that the length of a pendulum is the only factor affecting the frequency.

Grade 11

Assessment Standards

COMMUNICATING AND PRESENTING INFORMATION AND SCIENTIFIC ARGUMENTS

We know this when the learner is able to:

- Communicate information and present scientific arguments with clarity and precision.

Attainment is evident when the learner, for example,

- discusses the development of modern electronic devices and presents arguments to explain advantages of using them;
- argues which motor will produce the greatest turning effect by referring to appropriate factors;
- presents a scientific argument on the use of nuclear reactors for the generation of electricity.

Grade 12

Assessment Standards

COMMUNICATING AND PRESENTING INFORMATION AND SCIENTIFIC ARGUMENTS

We know this when the learner is able to:

- Communicate and defend scientific arguments with clarity and precision.

Attainment is evident when the learner, for example,

- formulates and defends scientific arguments for wearing safety belts;
- formulates and defends scientific arguments around the compulsory installation of air-bags in all means of transport;
- presents scientific arguments on the risks and benefits of the combustion of organic products and the manufacturing of synthetic products on human development, society and the environment;
- explains the dangers associated with the use of organic solvents and other organic products like combustibility and toxicity, and presents scientific arguments against the use of synthetic organic solvents.

Grade 10

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.

Progression in this outcome is reflected by the increase in the quantity and depth of understanding of concepts used, together with an increasing understanding of the connections between different concepts in order to develop a well-organised knowledge base.

Assessment Standards

RECALLING, STATING AND DISCUSSING PRESCRIBED CONCEPTS

We know this when the learner is able to:

- Recall and state basic prescribed scientific knowledge.

Attainment is evident when the learner, for example,

- states components of the atom (protons, electrons, neutrons, sub-atomic particles) and their characteristics;
- lists sources, uses and quantities of elements obtained from mining in South Africa;
- states and recognises that there are weak forces between and strong forces within molecules.

Grade 11

Assessment Standards

RECALLING, STATING AND DISCUSSING PRESCRIBED CONCEPTS

We know this when the learner is able to:

- Define and discuss basic prescribed scientific knowledge.

Attainment is evident when the learner, for example,

- defines the concepts of atomic number, mass number, atomic mass, isotope and radio-isotope;
- describes concepts and units related to electricity (e.g. electrical charge, electrical current and electron flow);
- states and explains the motor principle;
- describes oxidation and reduction in terms of the loss and the gain of electrons or the change in oxidation number.

Grade 12

Assessment Standards

RECALLING, STATING AND DISCUSSING PRESCRIBED CONCEPTS

We know this when the learner is able to:

- Define, discuss and explain prescribed scientific knowledge.

Attainment will be evident when the learner, for example,

- recalls and explains the concepts of distance, speed, time, acceleration, force and momentum;
- defines energy and explains the differences between different types of energy;
- discusses the characteristics of the carbon atom (referring to bonding and chain formation) and identifies the functional groups of common families (e.g. alkanes, alkenes, alcohols, acids, esters);
- describes electrochemical processes.

Grade 10

Learning Outcome 2 Continued

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.

Progression in this outcome is reflected by the increase in the quantity and depth of understanding of concepts used, together with an increasing understanding of the connections between different concepts in order to develop a well-organised knowledge base.

Assessment Standards

EXPLAINING RELATIONSHIPS

We know this when the learner is able to:

- Express and explain prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other.

Attainment is evident when the learner, for example,

- uses the atomic model of matter to explain howmelting and boiling temperature can be used to differentiate between substances having molecular and giant structures;
- explains the differences between elements, molecules and compounds.

APPLYING SCIENTIFIC KNOWLEDGE

- Apply scientific knowledge in familiar, simple contexts.

Attainment is evident when the learner, for example,

- identifies LEDs in circuits and knows the type and approximate voltage required for them to work.

Grade 11

Assessment Standards

EXPLAINING RELATIONSHIPS

We know this when the learner is able to:

- Express and explain prescribed scientific theories, models and laws by indicating the relationship between different facts and concepts in own words.

Attainment is evident when the learner, for example,

- describes the relationship between atomic number, mass number, atomic mass, isotope and radio-isotope;
- compares direct current and alternating current in qualitative terms, and explains the importance of alternating current in the transmission of electrical energy.

APPLYING SCIENTIFIC KNOWLEDGE

- Apply scientific knowledge in everyday life contexts.

Attainment is evident when the learner, for example,

- applies knowledge about electricity and magnetism to explain the working of transformers and builds a transformer;
- applies knowledge about radioactivity to explain the use of radio-carbon dating to determine the age of an artefact.

Grade 12

Assessment Standards

EXPLAINING RELATIONSHIPS

We know this when the learner is able to:

- Express and explain prescribed scientific principles, theories, models and laws by indicating the relationship between different facts and concepts in own words.

Attainment is evident when the learner, for example,

- indicates and explains the relationships between distance, time, mass, speed, force, acceleration, and balanced and unbalanced forces, and represents these relationships in more than one form;
- explains the principles underlying the use of distillation to separate organic compounds;
- describes, using basic knowledge about chemical reaction and structural formulae, typical organic reactions such as addition, combustion and polymerisation;

APPLYING SCIENTIFIC KNOWLEDGE

- Apply scientific knowledge in everyday life contexts.

Attainment is evident when the learner, for example,

- applies scientific knowledge to identify precautions that can be taken to avoid accidents;
- shows how energy transformation technologies are applied in everyday life;
- applies understanding of electrolysis to the production of chlorine in swimming pool chlorinators;
- uses available materials to construct an electrochemical cell.

Grade 10

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.

Progression in this Learning Outcome entails the relationship between knowledge systems and claims, and the increasing ability to analyse and evaluate their impact on socio-economic development in the wider world.

Assessment Standards

EVALUATING KNOWLEDGE CLAIMS

We know this when the learner is able to:

- Discuss knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge.

Attainment is evident when the learner, for example,

- uses scientific knowledge to explain why certain traditional practices are important;
- compares the changing interpretations of the nature and properties of matter.

Grade 11

Assessment Standards

EVALUATING KNOWLEDGE CLAIMS

We know this when the learner is able to:

- Recognise, discuss and compare the scientific value of knowledge claims in indigenous knowledge systems and explain the acceptance of different claims.

Attainment is evident when the learner, for example,

- traces and compares the historical development of different electronic technologies;
- compares the ways of explaining lightning by different communities;
- states controversies around the use of radioactivity.

Grade 12

Assessment Standards

EVALUATING KNOWLEDGE CLAIMS

We know this when the learner is able to:

- Research, discuss, compare and evaluate scientific and indigenous knowledge system knowledge claims by indicating the correlation among them, and explain the acceptance of different claims.

Attainment is evident when the learner, for example,

- compares and evaluates various explanations from different historical perspectives on the concept of force;
- researches and evaluates the suitability of alternative energy sources such as ethanol as a fuel, wind, solar and nuclear power, and discusses the acceptance of different viewpoints based on scientific knowledge.

Grade 10

Learning Outcome 3 Continued

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.

Progression in this Learning Outcome entails the relationship between knowledge systems and claims, and the increasing ability to analyse and evaluate their impact on socio-economic development in the wider world.

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON HUMAN DEVELOPMENT

We know this when the learner is able to:

- Describe the interrelationship and impact of science and technology on socio-economic and human development.

Attainment is evident when the learner, for example,

- provides names, formulae and uses of elements and compounds in everyday life and describes their impact on the environment;
- states the impact of human demands on the resources and products in the earth's system;
- using scientific principles, summarises the dangers of ultra-violet radiation and the role of sunscreens.

Grade 11

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON HUMAN DEVELOPMENT

We know this when the learner is able to:

- Identify ethical and moral issues related to the development of science and technology and evaluate the impact (pros and cons) of the relationship from a personal viewpoint.

Attainment is evident when the learner, for example,

- identifies and discusses moral and economic issues related to the use of electronic devices to protect cellular phone users against radiation;
- discusses strategies and ethical issues related to using chemical substances in sport;
- identifies and discusses ethical and moral issues related to global warming.

Grade 12

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON HUMAN DEVELOPMENT

We know this when the learner is able to:

- Research case studies and present ethical and moral arguments from different perspectives to indicate the impact (pros and cons) of different scientific and technological applications.

Attainment is evident when the learner, for example,

- explains the impact on human beings of collisions during road accidents;
- explores the precautions that can be taken to avoid accidents and discusses the technologies used to minimise the effects of collisions;
- analyses and explains the relationship between force and motion with political, economic, environmental and safety issues in the development and use of transportation technologies;
- researches and presents arguments on the impact of organic reactions on the quality of human life and the environment;
- researches and presents arguments on the economic, social and environmental impact of various energy sources;
- identifies typical organic reactions that add value to life (e.g. combustion and addition polymerisation) and researches their impact on socio-economic development;
- explains the dangers and impact associated with the use of organic solvents and other organic products (e.g. combustibility, toxicity) and suggests intervention strategies;
- discusses ethical issues related to the use of newly-synthesised drugs without proper testing.

Grade 10

Learning Outcome 3 Continued

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.

Progression in this Learning Outcome entails the relationship between knowledge systems and claims, and the increasing ability to analyse and evaluate their impact on socio-economic development in the wider world.

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

We know this when the learner is able to:

- Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on the immediate environment.

Attainment is evident when the learner, for example,

- discusses the environmental challenges to proper management of elements and compounds as well as their safe use and disposal in everyday life.

Grade 11

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

We know this when the learner is able to:

- Evaluate the impact of scientific and technological knowledge on sustainable development of resources and suggest long-term and short-term strategies to improve the management of resources in the environment.

Attainment will be evident when the learner, for example,

- discusses scientific factors that influence the different type of reactions and how these are applied in industry and everyday life;
- explains the impact of electronic devices on society and the environment;
- describes the effects of acid rain on the process of corrosion of metals;
- mentions the applications of radioactivity and its impact on our lives and the environment.

Grade 12

Assessment Standards

EVALUATING THE IMPACT OF SCIENCE ON THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

We know this when the learner is able to:

- Evaluate the impact of scientific and technological research and indicate the contribution to the management, utilisation and development of resources to ensure sustainability continentally and globally.

Attainment is evident when the learner, for example,

- analyses and explains the relationship between force and motion with political, economic, environmental and safety issues in the development and use of transportation technologies;
- evaluates strategies used to determine the influence and impact of motion on the quality of life and the environment;
- analyses the sustainable use of energy;
- presents scientific arguments on the risks and benefits of combustion of organic products and manufacturing of synthetic products on human development, society and the environment;
- explains the impact on the environment of combustion of fossil fuels (organic compounds);
- presents a report on the social, environmental and economic consequences of the use and discarding of organic products.

CONTENT AND CONTEXTS FOR THE ATTAINMENT OF ASSESSMENT STANDARDS

In this section content and contexts are provided to support the attainment of the Assessment Standards. The content indicated needs to be dealt with in such a way as to assist the learner to progress towards the achievement of the Learning Outcomes. Content must serve the Learning Outcomes and not be an end in itself. The contexts suggested will enable the content to be embedded in situations which are meaningful to the learner and so assist learning and teaching. The teacher should be aware of and use local contexts, not necessarily indicated here, which could be more suited to the experiences of the learner.

Content and context, when aligned to the attainment of the Assessment Standards, provide a framework for the development of Learning Programmes. More detail regarding the link between the selection of an appropriate context and the influence that it will have on identifying the core knowledge and concepts is included in the Learning Programme Guidelines. Examples of how content and contexts could be used to attain the specified Assessment Standards are reflected above in the examples accompanying the Assessment Standards.

Certain factors must be kept in mind when the main content areas are used to attain the Assessment Standards. These are:

- The main content areas are neither Learning Outcomes nor Assessment Standards, but are vehicles to attain the Assessment Standards.
- The main content areas should not be over-emphasised and distract teachers from focusing on the Learning Outcomes, but must support them to guide learners towards attaining the Assessment Standards in an integrated way.
- The main content areas are applicable when dealing with all three Learning Outcomes.
- The main content areas can be arranged in any order in a grade. Care should be taken to ensure that, among others, the principles of progression and integration are adhered to. For example, knowledge – which is foundational to others – should be dealt with first.
- The main content areas have the same weighting.
- The main content areas do not specify the depth or the level. This will be determined by the Assessment Standards.
- The main content areas will be taught in a relevant context, taking into account available resources, the local environment and the needs of South Africans.
- The main content areas do not limit teachers to one context.

It is impossible to study all knowledge and concepts in the Physical Sciences. The criteria used to select core knowledge and concepts were derived from Learning Outcomes, Assessment Standards (specified in this chapter), and the principles underpinning the National Curriculum Statement Grades 10-12 (General) (discussed in Chapter 1). In addition, the following factors were taken into consideration when selecting core knowledge and concepts:

- Foundational knowledge that builds on the General Education and Training band should be dealt with first.

This will provide the basis for further knowledge. Concepts within each knowledge area will build upon one another from one grade to the next.

- Maintaining a balance between physics and chemistry.
- Progression from simple to more complex knowledge with higher cognitive demands.
- Conceptual progression from one grade to the next.
- Conceptual coherence both within each grade and between grades.
- Aspects of all six core knowledge areas will be covered in each grade.
- Knowledge and concepts that have vast practical significance and relevance, such as natural products with possible indigenous knowledge system links to industry, nutrition, health and biology, as well as building a foundation for future science careers and further learning

Core knowledge and concepts

The core defines the *minimum* requirements for each grade. Percentages included in the tables for Learning Outcome 2 show the amount of time to be spent on each core knowledge area.

Grade 10

Learning Outcome 1

Practical Scientific Inquiry and Problem-solving Skills

The learner is able to use process skills, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.

Note: Each knowledge area comprises themes. These themes are underlined. Each theme comprises core concepts.

- Each theme must include at least ONE activity involving practical investigation and/or data interpretation linked to an opportunity for communicating and presenting information and scientific arguments.

Grade 11

- Each theme must include at least ONE activity involving practical investigation and/or data interpretation linked to an opportunity for communicating and presenting information and scientific arguments.

Grade 12

- Each theme must include at least ONE activity involving practical investigation and/or data interpretation linked to an opportunity for communicating and presenting information and scientific arguments.

Grade 10

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

MECHANICS
12,5%

- **Motion in one dimension:**
  - position, displacement, distance;
  - speed, average velocity, instantaneous velocity;
  - acceleration;
  - description of motion in words, diagrams, graphs and equations;
  - frames of reference.

- **Gravity and mechanical energy:**
  - weight (force exerted by the earth on an object);
  - acceleration due to gravity (acceleration resulting from the force exerted by the earth);
  - gravitational potential energy;
  - kinetic energy;
  - mechanical energy (sum of gravitational potential energy and kinetic energy);
  - conservation of mechanical energy (in the absence of dissipative forces).

Grade 11

MECHANICS
12,5%

- **Force, momentum and impulse:**
  - pairs of interacting objects exert equal forces on each other (Newton's Third Law);
  - momentum;
  - a net force on an object causes a change in momentum – if there is no net force on an object/system its momentum will not change (momentum will be conserved);
  - impulse (product of net force and time for which it acts on an object, momentum change);
  - a net force causes an object to accelerate (Newton's Second Law);
  - objects in contact exert forces on each other (e.g. normal force, frictional force);
  - masses can exert forces on each other (gravitational attraction) without being in contact, fields;
  - force between two masses (Newton's Law of Universal Gravitation);
  - moment of force, mechanical advantage.

Grade 12

MECHANICS
12,5%

- **Motion in two dimensions:**
  - projectile motion represented in words, diagrams, equations and graphs;
  - conservation of momentum in 2D;
  - frames of reference.

- **Work, power and energy:**
  - when a force exerted on an object causes it to move, work is done on the object (except if the force and displacement are at right angles to each other);
  - the work done by an external force on an object/system equals the change in mechanical energy of the object/system;
  - power (rate at which work is done).

Grade 10

Learning Outcome 2 Continued

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

WAVES, SOUND AND LIGHT 12,5%

- **Transverse pulses on a string or spring:**
  - pulse length, amplitude, speed;
  - graphs of particle position, displacement, velocity, acceleration;
  - transmission and reflection at a boundary between two springs (or strings);
  - relation of pulse speed to medium;
  - reflection from a fixed end and a free end;
  - superposition.
- **Transverse waves:**
  - wavelength, frequency, amplitude, period, wave speed;
  - particle position, displacement, velocity, acceleration;
  - standing waves with rent boundary conditions (free and fixed end) as a kind of superposition.
- **Geometrical optics:**
  - light rays;
  - reflection;
  - refraction (change of wave speed in different media);
  - mirrors;
  - total internal reflection, fibre optics in endoscopes and telecommunications.

Grade 11

WAVES, SOUND AND LIGHT 12,5%

- **Geometrical optics:**
  - lenses, image formation, gravitational lenses, spectacles, the eye;
  - telescopes, SALT;
  - microscopes.
- **Longitudinal waves:**
  - on a spring;
  - wavelength, frequency, amplitude, period, wave speed;
  - particle position, displacement, velocity, acceleration;
  - sound waves.
- **Sound:**
  - pitch, loudness, quality (tone);
  - physics of the ear and hearing;
  - ultrasound.
- **Physics of music:**
  - standing waves in different kinds of instruments.

Grade 12

WAVES, SOUND AND LIGHT 12,5%

- **Doppler Effect (source moves relative to observer):**
  - with sound and ultrasound;
  - with light – red shifts in the universe (evidence for the expanding universe).
- **Colour:**
  - relationship to wavelength and frequency;
  - pigments, paints;
  - addition and subtraction of light.
- **2D and 3D wavefronts:**
  - diffraction;
  - interference (special kind of superposition);
  - shock waves, sonic boom.
- **Wave nature of matter:**
  - de Broglie wavelength;
  - electron microscope.

Grade 10

Learning Outcome 2 Continued

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

ELECTRICITY AND MAGNETISM 12,5%

- **Magnetism:**
  - magnetic field of permanent magnets;
  - poles of permanent magnets, attraction and repulsion;
  - Earth's magnetic field, compass.

- **Electrostatics:**
  - two kinds of charge;
  - force between charges (descriptive);
  - attraction between charged and uncharged objects (polarisation);
  - conductors and insulators.

- **Electric circuits:**
  - need for a closed circuit for charges to flow;
  - electrical potential difference (voltage);
  - current;
  - resistance;
  - principles and instruments of measurement of voltage (P.D.), current and resistance.

Grade 11

ELECTRICITY AND MAGNETISM 12,5%

- **Electrostatics:**
  - force between charges (Coulomb's Law);
  - electric field around single charges and groups of charges;
  - electrical potential energy and potential;
  - capacitance, physics of the parallel plate capacitor, relation between charge, potential difference and capacitance;
  - capacitor as a circuit device.

- **Electromagnetism:**
  - magnetic field associated with current;
  - current induced by changing magnetic field
  - – transformers;
  - motion of a charged particle in a magnetic field.

- **Electric circuits:**
  - relation between current, voltage and resistance (Ohm's Law);
  - resistance, equivalent resistance, internal resistance;
  - series, parallel networks;
  - Wheatstone bridge.

Grade 12

ELECTRICITY AND MAGNETISM 12,5%

- **Electrodynamics:**
  - electrical machines (generators, motors);
  - alternating current;
  - capacitance and inductance.

- **Electronics:**
  - capacitive and inductive circuits;
  - filters and signal tuning;
  - active circuit elements, diode, LED and field effect transistor, operational amplifier;
  - principles of digital electronics – logical gates, counting circuits.

- **Electromagnetic radiation:**
  - dual (particle/wave) nature of EM radiation;
  - nature of an EM-wave as mutual induction of oscillating magnetic/electric fields;
  - EM spectrum;
  - nature of EM as particle – energy of a photon related to frequency and wavelength;
  - penetrating ability.

Grade 10

Learning Outcome 2 Continued

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

MATTER AND MATERIALS
25 %

- **Observing, describing, classifying and using materials - a macroscopic view**
  - The material(s) of which an object is composed.
  - Mixtures: heterogeneous and homogeneous.
  - Pure substances: elements and compounds.
  - Names and formulae of substances.
  - Metals, semimetals and nonmetals.
  - Electrical conductors, semiconductors and insulators.
  - Thermal conductors and insulators.
  - Magnetic and nonmagnetic materials.

- **Particles substances are made of**
  - Atoms and molecules (simple and giant)
  - Linking macroscopic properties of materials to micro (particle) structure.
  - Intermolecular and intramolecular forces (chemical bonds). Physical state and density explained in terms of these forces. Particle kinetic energy and temperature.

- **The Atom: basic building block of all matter**
  - Models of the atom.
  - Atomic mass and diameter.
  - Structure of the atom: protons, neutrons, electrons.
  - Isotopes
  - Energy quantization and electron configuration.
  - Periodicity of ionization energy to support the arrangement of the atoms in the Periodic Table.
  - Successive ionization energies to provide evidence for the arrangement of electrons into core and valence electrons.

Grade 11

MATTER AND MATERIALS
25 %

- **Electronic properties of matter:**
  - conduction in semiconductors, metals, ionic liquids;
  - intrinsic properties and doping – properties by design;
  - principles of the p-n junction and the junction diode;
  - insulators, breakdown.

- **Atomic combinations: molecular structure**
  - A chemical bond as the net electrostatic force between two atoms sharing electrons.
  - Chemical bonds as explained by Lewis theory and represented using Lewis diagrams.
  - Electronegativity of atoms to explain the polarity of bonds.
  - Oxidation number of atoms in molecules to explain their relative "richness,, in electrons.
  - Bond energy and length.
  - Multiple bonds.
  - Molecular shape as predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory.

- **Atomic nuclei:**
  - nuclear structure and stability;
  - radioactivity;
  - ionising radiation;
  - rission and fusion and their consequences;
  - nucleosynthesis – the Sun and stars;
  - age determination in geology and archaeology.

- **Ideal gases and thermal properties:**
  - motion of particles;
  - kinetic theory of gases;
  - temperature and heating, pressure;
  - ideal gas law.

Grade 12

MATTER AND MATERIALS
25 %

- **Optical phenomena and properties of materials:**
  - transmission and scattering of light;
  - emission and absorption spectra;
  - lasers;
  - photoelectric effect.

- **Organic molecules:**
  - organic molecular structures – functional groups, saturated and unsaturated structures, isomers;
  - systematic naming and formulae, structure-physical property relationships;
  - substitution, addition and elimination reactions.

- **Mechanical properties:**
  - elasticity, plasticity, fracture, creep (descriptive);
  - Hooke's Law, stress-strain, ductile and brittle materials;
  - fracture, strength of materials.

- **Organic macromolecules:**
  - plastics and polymers – thermoplastic and thermoset;
  - biological macromolecules – structure, properties, function.

Grade 10

Learning Outcome 2 Continued

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

CHEMICAL CHANGE
18,75 %

- **Physical and Chemical Change**
  - Microscopic interpretation of macroscopic changes (for example changes in conductivity and temperature)
  - Separation of particles in decomposition and synthesis reactions
  - Conservation of atoms and mass.
  - Law of constant composition
  - Conservation of energy
  - Volume relationships in gaseous reactions.

- **Representing chemical change**
  - Balanced chemical equations

Grade 11

CHEMICAL CHANGE
18,75 %

- **Quantitative aspects of chemical change:**
  - atomic weights;
  - molecular and formula weights;
  - determining the composition of substances;
  - amount of substance (mole), molar volume of gases, concentration;
  - stoichiometric calculations.

- **Energy and chemical change:**
  - energy changes in reactions related to bond energy changes;
  - exothermic and endothermic reactions;
  - activation energy.

- **Types of reaction:**
  - acid-base and redox reactions;
  - substitution, addition and elimination.

Grade 12

CHEMICAL CHANGE
18,75 %

- **Rate and Extent of Reaction:**
  - rates of reaction and factors affecting rate (nature of reacting substances, concentration [pressure for gases], temperature and presence of a catalyst);
  - measuring rates of reaction;
  - mechanism of reaction and of catalysis;
  - chemical equilibrium and factors affecting equilibrium;
  - equilibrium constant;
  - application of equilibrium principles.

- **Electrochemical reactions:**
  - electrolytic and galvanic cells;
  - relation of current and potential to rate and equilibrium;
  - understanding of the processes and redox reactions taking place in cells;
  - standard electrode potentials;
  - writing of equations representing oxidation and reduction half reactions and redox reactions.

Grade 10

Learning Outcome 2 Continued

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.

Note: The core concepts to be learned are included under the underlined theme and form a coherent whole.

CHEMICAL SYSTEMS
18,75 %

- **Global cycles:**
  - * The water cycle:
    - Physical changes and energy transfers: The movement of water from the ocean and land surfaces as controlled by energy in sunlight. Reservoirs for water on Earth.
    - Macroscopic properties of the three phases of water related to their microscopic structure.
  - * The nitrogen cycle:
    - Chemical changes and energy transfers. The movement of nitrogen between interrelated biological and geological systems.
    - Industrial fixation of nitrogen

- **The hydrosphere**
  - * Its composition and interaction with other global systems.
  - * Ions in aqueous solution: their interaction and effects.
    - Electrolytes and extent of ionization as measured by conductivity
    - Precipitation reactions.

Grade 11

CHEMICAL SYSTEMS
18,75 %

- **Exploiting the lithosphere/Earth's crust:**
  - mining and mineral processing – gold, iron, phosphate, (South Africa's strengths); environmental impact of these activities;
  - energy resources and their use.

- **The atmosphere:**
  - atmospheric chemistry;
  - global warming and the environmental impact of population growth.

Grade 12

CHEMICAL SYSTEMS
18,75 %

- **Chemical industry – resources, needs and the chemical connection:**
  - SASOL, fuels, monomers and polymers, polymerisation;
  - the chloralkali industry (soap, PVC, etc);
  - the fertiliser industry (N, P, K).
  - batteries, torch, car, etc.

Grade 10

Learning Outcome 3

The Nature of Science and its Relationship 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.

Note: The contexts provide the means through which core concepts can be used to attain Assessment Standards.

MECHANICS
12,5%

- Possible contexts could include:
  - transportation;
  - planets and their movement;
  - astronomy, cosmology;
  - machines and mechanics;
  - structures, including architecture;
  - weather systems.

WAVES, SOUND AND LIGHT
12,5%

- Possible contexts could include:
  - communication;
  - medical technologies, sonar;
  - astronomical instruments;
  - starlight and sunlight, microwaves;
  - astronomical and terrestrial speed determination, cosmology;
  - cellular communications;
  - solar energy

ELECTRICITY AND MAGNETISM
12,5%

- Possible contexts could include:
  - information technologies;
  - social and societal changes;
  - digital (e-)communications;
  - medical technologies;
  - storage and transport of energy;
  - lightning as electric/capacitative discharge;
  - cellular communications;
  - power generation, power grid;
  - solar energy.

Grade 11

MECHANICS
12,5%

- Possible contexts could include:
  - transportation;
  - movement;
  - astronomy, cosmology;
  - road accidents;
  - structures.

WAVES, SOUND AND LIGHT
12,5%

- Possible contexts could include:
  - communication;
  - medical technologies;
  - astronomical instruments;
  - starlight and sunlight;
  - eyes, human and animal;
  - earthquakes.

ELECTRICITY AND MAGNETISM
12,5%

- Possible contexts could include:
  - medical technologies;
  - communication;
  - storage and transport of energy;
  - ESKOM power grid;
  - lightning as electric/capacitative discharge;
  - aurora, cyclotrons.

Grade 12

MECHANICS
12,5%

- Possible contexts could include:
  - transportation;
  - planets and their movement;
  - astronomy, cosmology;
  - machines and mechanics;
  - structures, including architecture;
  - weather systems

WAVES, SOUND AND LIGHT
12,5%

- Possible contexts could include:
  - communication;
  - medical technologies, sonar;
  - astronomical instruments;
  - starlight and sunlight, microwaves;
  - astronomical and terrestrial speed determination, cosmology;
  - cellular communications;
  - solar energy.

ELECTRICITY AND MAGNETISM
12,5%

- Possible contexts could include:
  - information technologies;
  - social and societal changes;
  - digital (e-)communications;
  - medical technologies;
  - storage and transport of energy;
  - lightning as electric/capacitative discharge;
  - cellular communications;
  - power generation, power grid;
  - solar energy.

Grade 10

Learning Outcome 3 Continued

The Nature of Science and its Relationship 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.

Note: The contexts provide the means through which core concepts can be used to attain Assessment Standards.

MATTER AND MATERIALS 25 %

- Possible contexts could include:
  - chemistry around us;
  - chemistry in the home;
  - strengths of materials.

CHEMICAL CHANGE 18,75 %

- Possible contexts could include:
  - chemistry in the home;
  - human nutrition.

CHEMICAL SYSTEMS 18,75 %

- Possible contexts could include:
  - waste management;
  - water management.

Grade 11

MATTER AND MATERIALS
25 %

- Possible contexts could include:
  - chemistry in the home;
  - strength of materials;
  - nuclear energy in South Africa;
  - uses of nuclear technology;
  - radioactivity in medicine.

CHEMICAL CHANGE
18,75 %

- Possible contexts could include:
  - alternative fuel;
  - mining and mineral processing.

CHEMICAL SYSTEMS
18,75 %

- Possible contexts could include:
  - waste management;
  - mining and mineral processing;
  - alternative energy sources;
  - pollution, dealing with pollution and its prevention.

Grade 12

MATTER AND MATERIALS
25 %

- Possible contexts could include:
  - chemistry in the home;
  - science in fashion;
  - medical and industrial uses of lasers;
  - astrophysics;
  - civil engineering.

CHEMICAL CHANGE
18,75 %

- Possible contexts could include:
  - mining and mineral processing;
  - polymers, paints and plastic.

CHEMICAL SYSTEMS
18,75 %

- Possible contexts could include:
  - waste management;
  - mining and mineral processing;
  - cosmetology.

CHAPTER 4

ASSESSMENT

INTRODUCTION

Assessment is a critical element of the National Curriculum Statement Grades 10 – 12 (General). It is a process of collecting and interpreting evidence in order to determine the learner's progress in learning and to make a judgement about a learner's performance. Evidence can be collected at different times and places, and with the use of various methods, instruments, modes and media.

To ensure that assessment results can be accessed and used for various purposes at a future date, the results have to be recorded. There are various approaches to recording learners' performances. Some of these are explored in this chapter. Others are dealt with in a more subject-specific manner in the Learning Programme Guidelines.

Many stakeholders have an interest in how learners perform in Grades 10 – 12. These include the learners themselves, parents, guardians, sponsors, provincial departments of education, the Department of Education, the Ministry of Education, employers, and higher education and training institutions. In order to facilitate access to learners' overall performances and to inferences on learners' competences, assessment results have to be reported. There are many ways of reporting. The Learning Programme Guidelines and the Assessment Guidelines discuss ways of recording and reporting on school-based and external assessment as well as giving guidance on assessment issues specific to the subject.

WHY ASSESS

Before a teacher assesses learners, it is crucial that the purposes of the assessment be clear and unambiguous. Understanding the purposes of assessment ensures that an appropriate match exists between the purposes and the methods of assessment. This, in turn, will help to ensure that decisions and conclusions based on the assessment are fair and appropriate for the particular purpose or purposes.

There are many reasons why learners' performance is assessed. These include monitoring progress and providing feedback, diagnosing or remediating barriers to learning, selection, guidance, supporting learning, certification and promotion.

In this curriculum, learning and assessment are very closely linked. Assessment helps learners to gauge the value of their learning. It gives them information about their own progress and enables them to take control of and to make decisions about their learning. In this sense, assessment provides information about whether teaching and learning is succeeding in getting closer to the specified Learning Outcomes. When assessment indicates lack of progress, teaching and learning plans should be changed accordingly.

TYPES OF ASSESSMENT

This section discusses the following types of assessment:

- baseline assessment;
- diagnostic assessment;
- formative assessment; and
- summative assessment.

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.

Diagnostic assessment

Any assessment can be used for diagnostic purposes – that is, to discover the cause or causes of a learning barrier. Diagnostic assessment 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.

Formative assessment

Any form of assessment that is used to give feedback to the learner is fulfilling a formative purpose. 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 the progress of learners. Constructive feedback is a vital component of assessment for formative purposes.

Summative assessment

When assessment is used to record a judgement of the competence or performance of the learner, it serves a summative purpose. Summative assessment gives a picture of a learner's competence or progress at any specific moment. It can occur at the end of a single learning activity, a unit, cycle, term, semester or year of learning. Summative assessment should be planned and a variety of assessment instruments and strategies should be used to enable learners to demonstrate competence.

WHAT SHOULD ASSESSMENT BE AND DO?

Assessment should:

- 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.

HOW TO ASSESS

Teachers' assessment of learners' performances 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 through assessment should also show a great degree of validity; that is, they should be made on the aspects of learning that were assessed.

Because each assessment cannot be totally valid or reliable by itself, decisions on learner progress must be based on more than one assessment. This is the principle behind continuous assessment (CASS). Continuous assessment is a strategy that bases decisions about learning on a range of different assessment activities and events that happen at different times throughout 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. Different subjects have different requirements for what should be included in the portfolio. The Learning Programme Guidelines discuss these requirements further.

Continuous assessment 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.

Continuous assessment should be applied both to sections of the curriculum that are best assessed through written tests and assignments and those that are best assessed through other methods, such as by performance, using practical or spoken evidence of learning.

METHODS OF ASSESSMENT

Self-assessment

All Learning Outcomes and Assessment Standards are transparent. Learners know what is expected of them. Learners can, therefore, play an important part, through self-assessment, in 'pre-assessing' work before the teacher does the final assessment. Reflection on one's own learning is a vital component of learning.

Peer assessment

Peer assessment, using a checklist or rubric, helps both the learners whose work is being assessed and the learners who are doing the assessment. The sharing of the criteria for assessment empowers learners to evaluate their own and others' performances.

Group assessment

The ability to work effectively in groups is one of the Critical Outcomes. Assessing group work involves looking for evidence that the group of learners co-operate, assist one another, divide work, and combine individual contributions into a single composite assessable product. Group assessment looks at process as well as product. It involves assessing social skills, time management, resource management and group dynamics, as well as the output of the group.

METHODS OF COLLECTING ASSESSMENT EVIDENCE

There are various methods of collecting evidence. Some of these are discussed below.

Observation-based assessment

Observation-based assessment methods tend to be less structured and allow the development of a record of different kinds of evidence for different learners at different times. This kind of assessment is often based on tasks that require learners to interact with one another in pursuit of a common solution or product. Observation has to be intentional and should be conducted with the help of an appropriate observation instrument.

Test-based assessment

Test-based assessment is more structured, and enables teachers to gather the same evidence for all learners in the same way and at the same time. This kind of assessment creates evidence of learning that is verified by a specific score. If used correctly, tests and examinations are an important part of the curriculum because they give good evidence of what has been learned.

Task-based assessment

Task-based or performance assessment methods aim to show whether learners can apply the skills and knowledge they have learned in unfamiliar contexts or in contexts outside of the classroom. Performance assessment also covers the practical components of subjects by determining how learners put theory into practice. The criteria, standards or rules by which the task will be assessed are described in rubrics or task checklists, and help the teacher to use professional judgement to assess each learner's performance.

RECORDING AND REPORTING

Recording and reporting involves the capturing of data collected during assessment so that it can be logically analysed and published in an accurate and understandable way.

Methods of recording

There are different methods of recording. It is often difficult to separate methods of recording from methods of evaluating learners' performances.

The following are examples of different types of recording instruments:

- rating scales;
- task lists or checklists; and
- rubrics.

Each is discussed below.

Rating scales

Rating scales are any marking system where a symbol (such as A or B) or a mark (such as 5/10 or 50%) is defined in detail to link the coded score to a description of the competences that are required to achieve that score. The detail is more important than the coded score in the process of teaching and learning, as it gives learners a much clearer idea of what has been achieved and where and why their learning has fallen short of the target. Traditional marking tended to use rating scales without the descriptive details, making it difficult to have a sense of the learners' strengths and weaknesses in terms of intended outcomes. A six-point scale of achievement is used in the National Curriculum Statement Grades 10 – 12 (General).

Task lists or checklists

Task lists or checklists consist of discrete statements describing the expected performance in a particular task. When a particular statement (criterion) on the checklist can be observed as having been satisfied by a learner during a performance, the statement is ticked off. All the statements that have been ticked off on the list (as criteria that have been met) describe the learner's performance. These checklists are very useful in peer or group assessment activities.

Rubrics

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. Rubrics require teachers to know exactly what is required by the outcome. Rubrics can be holistic, giving a global picture of the standard required, or analytic, giving a clear picture of the distinct features that make up the criteria, or can combine both. The Learning Programme Guidelines give examples of subject-specific rubrics.

To design a rubric, a teacher has to decide the following:

- 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?
- What different assessment instruments best suit each part of the task (such as the process and the product)?
- What knowledge should be evident?
- What skills should be applied or actions taken?
- What opportunities for expressing personal opinions, values or attitudes arise in the task and which of these should be assessed and how?
- Should one rubric target all the Learning Outcomes and Assessment Standards of the task or does the task need several rubrics?
- How many rubrics are, in fact, needed for the task?

It is crucial that a teacher shares the rubric or rubrics for the task with the learners before they do the required task. The rubric clarifies what both the learning and the performance should be focus on. It becomes a powerful tool for self-assessment.

Reporting performance and achievement

Reporting performance and achievement informs all those involved with or interested in the learner's progress. Once the evidence has been collected and interpreted, teachers need to record a learner's achievements. Sufficient summative assessments need to be made so that a report can make a statement about the standard achieved by the learner.

The National Curriculum Statement Grades 10 – 12 (General) adopts a six-point scale of achievement. The scale is shown in Table 4.1.

Table 4.1 Scale of achievement for the National Curriculum Statement Grades 10 – 12 (General)

Rating Code	Description of Competence	Marks (%)
6	Outstanding	80-100
5	Meritorious	60-79
4	Satisfactory	50-59
3	Adequate	40-49
2	Partial	30-39
1	Inadequate	0-29

SUBJECT COMPETENCE DESCRIPTIONS

To assist with benchmarking the achievement of Learning Outcomes in Grades 10 – 12, subject competences have been described to distinguish the grade expectations of what learners must know and be able to achieve. Six levels of competence have been described for each subject for each grade. These descriptions will assist teachers to assess learners and place them in the correct rating. The descriptions summarise the Learning Outcomes and the Assessment Standards, and give the distinguishing features that fix the achievement for a particular rating. The various achievement levels and their corresponding percentage bands are as shown in Table 4.1.

In line with the principles and practice of outcomes-based assessment, all assessment – both school-based and external – should primarily be criterion-referenced. Marks could be used in evaluating specific assessment tasks, but the tasks should be assessed against rubrics instead of simply ticking correct answers and awarding marks in terms of the number of ticks. The statements of competence for a subject describe the minimum skills, knowledge, attitudes and values that a learner should demonstrate for achievement on each level of the rating scale.

When teachers/assessors prepare an assessment task or question, they must ensure that the task or question addresses an aspect of a particular outcome. The relevant Assessment Standard or Standards must be used when creating the rubric for assessing the task or question. The descriptions clearly indicate the minimum level of attainment for each category on the rating scale.

The competence descriptions for this subject appear at the end of this chapter.

PROMOTION

Promotion at Grade 10 and Grade 11 level will be based on internal assessment only, but must be based on the same conditions as those for the Further Education and Training Certificate. The requirements, conditions, and rules of combination and condonation are spelled out in the *Qualifications and Assessment Policy Framework for the Grades 10 – 12 (General).*

WHAT REPORT CARDS SHOULD LOOK LIKE

There are many ways to structure a report card, but the simpler the report card the better, provided that all important information is included. Report cards should include information about a learner's overall progress, including the following:

- the learning achievement against outcomes;
- the learner's strengths;
- the support needed or provided where relevant;
- constructive feedback commenting on the performance in relation to the learner's previous performance and the requirements of the subject; and
- the learner's developmental progress in learning how to learn.

In addition, report cards should include the following:

- name of school;
- name of learner;
- learner's grade;
- year and term;
- space for signature of parent or guardian;
- signature of teacher and of principal;
- date;
- dates of closing and re-opening of school;
- school stamp; and
- school attendance profile of learner.

ASSESSMENT OF LEARNERS WHO EXPERIENCE BARRIERS TO LEARNING

The assessment of learners who experience any barriers to learning will be conducted in accordance with the recommended alternative and/or adaptive methods as stipulated in the *Qualifications and Assessment Policy Framework for Grades 10 – 12 (General)* as it relates to learners who experience barriers to learning. *Refer to White Paper 6 on Special Needs Education: Building an Inclusive Education and Training System.*

Grade 10

Code	Scale	Competence Descriptions
6	**80%-100% Outstanding**	**By the end of Grade 10 the learner with outstanding achievement can:**

- use critical thinking and given criteria to evaluate generated solutions to problem solving;
- record qualitative and quantitative scientific information accurately to gauge reliability, and present findings and conclusions to scientific investigations in a composite report according to the prescribed criteria;
- present scientific data and findings to a set audience and in a set context by using more than two models;
- apply scientific knowledge to different contexts, and elaborate on indigenous scientific knowledge and empiricism as worldviews on knowledge claims;
- apply scientific knowledge to evaluate ethical and moral issues that arise from scientific and technological applications;
- recommend alternatives that will improve the management of natural resources and the environment.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with outstanding achievement can:

- adapt procedures and processes to achieve a solution to a posed problem, and analyse problem-solving processes and solutions generated using given criteria;
- develop an action plan indicating the equipment/tools to be used, procedural instructions, and safety and precautionary procedures to be taken, and conduct the scientific investigation alone;
- evaluate and explain patterns between variables in a qualitative manner using Physical Sciences concepts, and use specific numeric, symbolic, graphical or linguistic (essays) models to display data to a set audience and in a different context;
- using the conclusions to a scientific problem, construct generalisations and apply scientific knowledge in everyday life contexts;
- trace the origin of scientific knowledge (Western or indigenous knowledge systems), illustrate how traditional practices were used from different cultural backgrounds, and analyse the value of these traditional practices;
- compare and evaluate the perspectives of three stakeholders regarding the use of the scientific and technological applications and suggest justifiable short-term and long-term alternatives to improve the management of natural resources and the environment.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with outstanding achievement can:

- apply scientific knowledge in everyday life contexts, analyse and evaluate scientific knowledge and indigenous knowledge system claims by indicating the correlation among them, and explain the acceptance of different claims;
- formulate a scientific investigable problem when presented with a complex scenario, and develop and apply own criteria to analyse and evaluate problem-solving processes and solutions generated;
- evaluate findings, select and use appropriate terminology to condense information, present it in a composite report according to the prescribed criteria, and adapt the report for different purposes and different audiences;
- evaluate different perspectives and suggest a justifiable decision regarding the application of a specific technology, its scientific nature and its ability to explain phenomena, events, and occurrences;
- assess South Africa's contribution to management, utilisation and development of resources and the environment to ensure global sustainability.

Grade 10

Code	Scale	Competence Descriptions
5	**60%-79% Meritorious**	**By the end of Grade 10 the learner with meritorious achievement can:**

- generate own problem-solving solutions using critical thinking skills;
- predict what will happen to the results of a scientific investigation when one variable is modified;
- communicate information and conclusions to scientific investigations with clarity and precision, and display data to a set audience and context using more than one model;
- transfer knowledge of some concepts to new contexts and use this knowledge to construct new physical science structures;
- understand that Mainstream science is not the only way of looking at and explaining phenomena;
- identify a factor that influences knowledge claims so that they are not a neutral process;
- evaluate the pros and cons of a technological application and suggest an alternative regarding the application;
- measure the impact of scientific and technological applications on natural resources and the environment.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with meritorious achievement can:

- develop an understanding and is able to construct scientific knowledge by establishing connections between concepts and explain how scientific knowledge claims influence each other;
- identify factors that influence knowledge claims to illustrate that they are not a neutral process;
- generate a solution procedure, identify all variables and indicate their effect on the results while making reference to independent and dependent variables and using critical thinking and logical reasoning skills in a scientific investigation;
- record scientific information qualitatively and quantitatively, and present the gathered scientific information in different representational forms (e.g. tables, graphs) to show patterns and trends and draw logical conclusions;
- discuss and compare different cultural explanations for natural phenomena, events and occurrences with reference to the scientific knowledge embedded in them.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with meritorious achievement can:

- uncover connections between concepts and transfer them to new contexts to establish concept webs, and evaluate the philosophy that supports the development of a scientific theory;
- analyse and evaluate problem-solving processes and solutions generated using given criteria, but also to adapt and manipulate procedures and processes to achieve a solution for changed scenarios or operating contexts;
- use Physical Sciences concepts to explain the patterns and relationships between variables during a scientific investigation in a qualitative manner;
- analyse the scientific value of traditional practices and how scientific development has influenced the transition from traditional practices to modern scientific application and technologies and vice versa;
- evaluate ethical and moral issues that arise from science and technology applications and recommend short-term and long-term alternatives to improve the management of natural resources and the environment.

Grade 10

Code	Scale	Competence Descriptions
4	**50%-59% Satisfactory**	**By the end of Grade 10 the learner with satisfactory achievement can:** ■ identify an investigable problem when presented with a simple scenario and formulate a scientifically investigable question from given information; ■ test predictions, communicate findings symbolically or linguistically, and indicate some of the relationships between different concepts and facts; ■ demonstrate an understanding that scientific knowledge is tentative, that explanations of phenomena are open to change, and that theories must be verified; ■ understand that Mainstream science is not the only way of looking at and explaining phenomena (this understanding manifests itself in a learner identifying and discussing different cultural explanations for a natural phenomenon, event, or occurrence); ■ compare different scientific and logical applications.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with satisfactory achievement can:

- indicate the relationship between different facts and concepts in own words, thereby expressing and explaining prescribed scientific theories, models and laws;
- select and use appropriate terminology to condense information and indicate relationships;
- state ways in which verification of theories should take place;
- recognise that scientific knowledge is tentative and explanations of phenomena are open to change;
- identify factors that influence knowledge claims to illustrate that they are not a neutral process;
- formulate a scientifically investigable problem when presented with a scenario, conduct a scientific investigation to test predictions and hypothesis, individually, and discuss the patterns between dependent and independent variables;
- communicate information and conclusions to scientific investigations with clarity and precision and display data to a set audience and context using more than one model;
- compare scientific concepts and principles in traditional practices with examples of modern scientific application.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with satisfactory achievement can:

- indicate the relationship between different facts and concepts in own words;
- explain prescribed scientific principles, theories, models and laws;
- explain how two worldviews on scientific knowledge claims influence each other;
- use critical and creative thinking and scientific reasoning to generate a solution procedure to solve the problem;
- conduct an experiment, test or problem-solving exercise with the necessary accuracy and precision and present data appropriately in various forms to show patterns and trends;
- identify factors that influence knowledge claims so that they are not a neutral process, and the scientific concepts and principles underlying the traditional practices from various cultural backgrounds;
- present different perspectives of various stakeholders with regard to the use of scientific and technological applications and measure their impact on natural resources and the environment.

Grade 10

Code	Scale	Competence Descriptions
3	**40%-49% Adequate**	**By the end of Grade 10 the learner with adequate achievement can:**

- identify a problem when presented with a simple scenario;
- collect scientific information from given sources and carry out procedures to solve the investigable problem;
- conduct a scientific investigation to test predictions on an investigable problem;
- use basic scientific conventions and SI units to communicate findings on a scientific investigation or problem-solving exercise;
- recall and state basic prescribed scientific concepts and knowledge;
- state and recognise relationships between different facts and concepts and the relationship of concepts with each other;
- understand and explain that the gathering of scientific information and facts is a continuous process, and trace how a scientific theory regarding nature has developed over time;
- independently identify a technological development in the local environment and explain ways in which scientific and technological development has impacted on people's lives;
- identify the scientific concepts and principles underlying a traditional practice or technology that is/was used in own or other communities.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with adequate achievement can:

- define and discuss basic prescribed scientific knowledge and illustrate how a scientific theory regarding nature has developed over time;
- explain that continuous development of scientific information and facts influences the development of scientific theories, models and laws;
- use different sources of information to solve the scientific problem task, individually and in groups, applying various procedures;
- in a group, develop an action plan and identify the patterns between dependent and independent variables and conduct a scientific investigation;
- test predictions, communicate findings symbolically or linguistically, and indicate some of relationships between different concepts and facts;
- identify scientific concepts and principles underlying the traditional practices that were used from different cultural backgrounds.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with adequate achievement can:

- define, discuss and explain prescribed scientific concepts and integrate several pieces of information and procedures from content knowledge across topics and disciplines to solve a problem task;
- generate a hypothesis and design, plan and conduct a scientific inquiry to collect data systematically with regard to accuracy, reliability and the need to control variables;
- present collected data appropriately in written or other forms to show patterns and trends, and summarise findings using appropriate scientific terminology, symbols, conventions and SI units;
- communicate or present scientific data and findings to a set audience and in a set context by using more than two models;
- explain that continuous development of scientific theories has to overcome certain beliefs and will continue to do so, and trace how a scientific theory regarding nature has developed over time;
- identify a technological development (industry-related) which has contributed to socio-economic and human development of a community and the environment;
- discuss and compare different cultural explanations for natural phenomena, events and occurrences with reference to the scientific knowledge embedded in them.

Grade 10

Code	Scale	Competence Descriptions
2	**30%-39% Partial**	**By the end of Grade 10 the learner with partial achievement can:** ■ recall basic scientific concepts and knowledge to a limited extent; ■ identify a problem from a simple scenario and follow instructions in order to carry out scientific investigations; ■ follow instructions to collect scientific information from given sources and communicate findings to a scientific investigation, using everyday language; ■ make a connection between scientific concepts and traditional practice; ■ describe how scientific theory regarding nature has developed over time; ■ describe how continuous development of scientific information and facts influences the development of scientific theories, models and laws.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with partial achievement can:

- recall basic prescribed scientific concepts, theories and facts and only state that continuous development of scientific information and facts influences the development of scientific theories models and laws;
- engage in critical problem-solving activities in a group, using given information and procedures;
- conduct scientific investigations to test predictions and hypothesis using a complete list of step-by-step instructions;
- use the basic scientific conventions and SI units to communicate findings on a scientific investigation or problem-solving exercise;
- identify the scientific concepts and principles underlying the traditional practices that were used from different cultural backgrounds and describe how a scientific theory regarding nature has developed over time;
- solve a problem by substitution but only if a relevant formula is given.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with partial achievement can:

- recall prescribed scientific concepts and theories;
- describe the nature of scientific theories and understand that continuous development of scientific theories has to overcome certain beliefs;
- solve the problem task critically in a group or individually;
- conduct a scientific investigation to test predictions and hypotheses using a list of instructions and scientific data;
- gather and format information in a logical manner;
- present scientific data and findings to a set audience and in a set context by using more than one model;
- identify two technological developments (industry-related) that have contributed to socio-economic and human development of a community and the environment

Grade 10

Code	Scale	Competence Descriptions
1	**0%-29%** **Inadequate**	**By the end of Grade 10 the learner with inadequate achievement can:** ■ recall terminology, symbols, conventions and SI units; ■ engage in illogical problem-solving activities but succeed only when the problem requires substitution of values in an equation; ■ when presented with a simple scenario and procedures to follow, collect incoherent and irrelevant data in an illogical manner; ■ explain concepts but relies on memorised facts to do so; ■ explain traditional practice in terms of beliefs; ■ see scientific knowledge as absolute and having an uncontested nature.

Grade 11

Competence Descriptions

By the end of Grade 11 the learner with inadequate achievement can:

- name basic prescribed scientific concepts, theories, laws and facts and describe a scientific theory regarding nature;
- see scientific knowledge as absolute but recognise that it is not complete (that is, more research can add to this knowledge);
- engage in non-critical problem-solving activities, whether in a group or individually, when presented with a given scenario;
- follow instructions to conduct a simple scientific investigation;
- communicate scientific findings and information using everyday non-scientific terms and conventions;
- identify a traditional practice that was used from different cultural backgrounds.

Grade 12

Competence Descriptions

By the end of Grade 12 the learner with inadequate achievement can:

- use non-critical thinking skills to solve a problem when presented with a simple scenario and conduct a scientific investigation using step-by-step instructions;
- communicate scientific findings and information using everyday language;
- describe the nature of scientific theories and identify a technological development (industry-related) which has contributed to socio-economic and human development of a community and the environment;
- describe different cultural explanations for natural phenomena, events and occurrences with reference to the scientific knowledge embedded in them.