Human Resource Development Council of South Africa

Maths and Science Standing Committee
Terms of Reference

Background

The Mathematics and Science Standing Committee was established by the Human Resource Development Council (HRDC) of South Africa to address challenges and opportunities in STEM (science, technology, engineering, and mathematics) disciplines (particularly in mathematics and science) at both basic and higher education levels in South Africa.

Being able to participate successfully in STEM subjects at primary and secondary school level has important implications for higher education and professional success. Currently, less than a third of students can be described as “competent” in terms of mathematical and scientific ability at basic education level, and less than 36% of students who are able to access tertiary education with their Matric qualification receive a score of more than 50% for Mathematics. Therefore, it is only a fraction of South African students who are able to access STEM-based tertiary education programmes. Of the students who do access these programmes, the majority are male, and South Africa is currently not able to produce sufficient graduates in STEM disciplines to meet its growing professional demands (Reddy, Bhorat, Powell, Visser, & Arends, 2016).

In relation to international trends, South Africa was among the lowest performing countries in the world for mathematics (38th out of 39 countries) and science (39th out of 39 countries) at grade 8/9 level for the Trends in International Mathematics and Science Study (TIMSS) in 2015. Although South Africa's performance in this study has shown improvement since 2003, it is clear that (a) access to and achievement in mathematics and science remains divided by socio-economic status, and (b) there are a number of areas in which we can improve our STEM education offerings (Reddy, Visser et al., 2016).

The work of the Standing Committee is a collaborative process and will reflect broad consultation with the wider mathematics and sciences communities. Key partners in this process include the Department of Higher Education and Training, Department of Science and Technology, Department of Basic Education, National Teachers' Unions, Universities South Africa as well as national associations in the different mathematics and science disciplines.

Mandate

The following areas comprise the mandate of the HRDC Mathematics and Science Standing Committee:

1. To provide advice and recommendations on

- Strategies to improve mathematics and science engagement and participation in public spaces including, but not limited to, community members, teachers, parents, and learners;
- Strategies to improve performance of students in mathematics and science at both basic and higher education levels including:
    - Development of clear mathematics and science learning standards, curricula and assessment tools;
    - Adequate preparation of basic education mathematics and science learners for tertiary education study in STEM disciplines;
    - Appropriate assessment standards for matric mathematics and science to ensure readiness for tertiary education.

- Strategies to improve the education of, and support for, basic education mathematics and science teachers, focusing on:

    - The selection of high quality students into mathematics and science Initial Teacher Education (ITE) programmes;
    - Curricula standards for ITE programmes in mathematics and science;
    - Initial and pre-service teacher education including qualification requirements and induction for mathematics and science teachers;
    - Nature, quality and support of continuing professional development programmes for in-service teachers;
    - Contributing towards the development of mathematics and science teacher professional standards;
    - Monitoring and evaluating the quality and impact of teacher education at initial teacher education, pre- and in-service levels;
    - The supply of suitably qualified mathematics and science teachers from foundation, intermediate to further education and training phases.

2. To publish advisory notes/policy briefs to guide decision-making in mathematics and science;

3. To co-ordinate and align preexisting initiatives in the areas of mathematics and science education to enable coherence, develop productive collaborations, and create greater impact of these initiatives;

4. To develop strategies to ensure representative, relevant, and useful long-term research and development for the mathematics and sciences in South Africa.

Governance, Operation and Financial Support

A chairperson appointed by the committee leads the work of the Standing Committee. Professor Mamokgethi Phakeng, from the University of Cape Town, was appointed as the Chairperson of the Standing Committee on 16 September 2016.

The HRDC will provide the Standing Committee with appropriate financial support for contracting: (a) a project manager for the purposes of conducting the required desktop research, and consultation community input and the preparation of a monthly report, and (b) an administrative assistant for the purposes of organising meetings, travel of Committee members to these meetings and all other administrative support that the chairperson and project manager may require.

Membership of the Standing Committee

The Standing Committee will be composed of representatives from key role players in the sector including but not limited to the following:

- The Department of Higher Education and Training (DHET)
- The Department of Basic Education (DBE)
- The Department of Science and Technology (DST)
- The South African Mathematics Foundation (SAMF)
- Universities South Africa (USAF) Human Sciences Research Council (HSRC)
- The South African Association for Science Education (SAASTE)
- Other key role players from the Mathematics and Science sector:
    - Organised Labour

During the course of its work, the Standing Committee, and expertise sourced by the Standing Committee, may consult key stakeholders. The Standing Committee should draw on research undertaken in South Africa on the state of mathematics and Science education and may commission work if it is deemed necessary. The task team will provide the HRDC with an interim report within the first six months of its appointment.

Conflicts of Interest and Confidentiality

All members must strictly comply with the Guidelines for the functioning of the HRDC of South Africa. Moreover, for the purpose of this exercise, a member will be considered to be in a situation of conflict of interest during a discussion on prioritisation of a specific endeavour that would directly benefit the member or the member's institution/organisation.

Members of the Standing Committee may not present the work of the Committee as theirs. Only the chairperson is mandated to make presentations to the HRDC and/or speak on behalf of the Standing Committee

HRDC
HUMAN RESOURCE DEVELOPMENT COUNCIL
of South Africa

MATHS AND SCIENCE STANDING COMMITTEE **PRE-SERVICE TEACHER EDUCATION** ***SCIENCE FOUNDATION PHASE***

SUBJECT: Science

Matter and Materials Knowledge Strand

Big Ideas	**Concepts**	**Topics**	**Expanding and deepening (KSVA)**
✓ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate. ✓ We can classify materials by their properties, in order to establish types and patterns. Properties determine the selection of materials for particular uses. ✓ We can modify materials in ways we choose, through our understanding of their substructure.	Matter and materials Properties of matter (matter and conservation of matter, phases of matter , mixtures and solutions.	▪ Phases of matter and phase changes, mixtures and solutions, soil, water and water cycle, air ▪ Soil, atmosphere, water cycle, phases of water and recycling,	- NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. - How does it change?- intuitive chemistry

		▪ Matter and conservation of matter.	
		▪ Separating mixtures	

Energy and change Knowledge Strand

Big Ideas	**Concepts**	**Topics**	**Expanding and deepening (KSVA)**
✓ Changing the movement of an object requires unbalanced forces to be acting on it. ✓ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen. ✓ Objects can affect other objects at a distance.	Transport	▪ Mechanics and mechanisms forces;measurements (intrinsic and extrinsic, eg. density)	- NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. Electricity applications
Big Ideas **Life and Living Knowledge Strand**	**Concepts**	**Topics**	**Expanding and deepening (KSVA)**
✓ Living things, including humans and invisibly small organisms, can be understood in terms of life processes, functional units and systems. ✓ Organisms in ecosystems are dependent for their survival on the presence of abiotic factors and on their relationship with other organisms. ✓ Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms	Living and non-living, muscular & skeletons (locomotion); sensors and interacting with the environment; Plants, animals and ecosystems	▪ Me and my body ▪ I am special ▪ How I am the same ▪ Sensors – interacting with the enviroment, & health. ▪ Food chains, wild animals, insect metamorphosis, and life cycles and germination	NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. How do I fit.
Big Ideas **Earth and Beyond Knowledge Strand**	**Concepts**	**Topics**	**Expanding and deepening (KSVA)**

✓ Our planet is a small part of a vast solar system in an immense galaxy. ✓ Our solar system is a very small part of one of billions of galaxies in the Universe	Solar systems	The sky at night (day/night, what the night sky looks like, the moon, the stars)	NOS- Relevant knowledge to society, context, and IKS, pluralistic science – discoveries

Recommendations for Foundation Phase Teacher Education

Recommendation 1: Early Childhood Education

Several universities offer Bachelor of Education programmes for Early Childhood Education. There should be a similar table of content developed for the Early Childhood Education phase or early science and technology programmes

Recommendation 2: The premise on which the teacher education curriculum is developed

What is the premise that the teacher education curriculum is developed on – the idea or theory on which the statement or action is based? This should be included in the preface to the curriculum document

Recommendation 3: Foundation Phase teacher education programmes should include a compulsory module for science and technology education

All B.Ed. in Foundation Phase Teaching programmes should include a module on science and technology education
This recommendation should be written into the curriculum for teacher education (revised MRTEQ)
All Foundation Phase Teaching programmes should have micro-teaching modules, which includes experiences for planning and presenting science and/or technology (engineering) lessons

Recommendation 4: The formation of Communities in Practice to reflect and adapt the topics and content presented in the document.

The CONTENT TABLES have been developed from the Topics that are listed in the CAPS curriculum document and do not necessarily reflect current thinking on early science education.

The CONTENT TABLES developed shows only content. The practical investigations that underlie the content should also be included.
The content column "expanding and deepening" (KSVA) e.g. Nature of Science, intuitive knowledge, IKS etc should be integrated in the topics and not as stand alone ideas

Topics listed should be extended to include relevant, contextual issues as part of case studies. An example of this is the topic on Me and My Body – currently the outbreak of measles – what does this mean in the lives of the children?

It is recommended that Communities in Practice are formed for the ECE, foundation phase and intermediate phase for science teacher education, made up of all HEIs. These communities in practice will reflect on the implementations of these science education modules and adapt the current tables of content as given here through these reflective practices.

Recommendation 5: Recommendations for furhter consideration on the CONTENT TABLES documents (page 7-11 of the document)

The document requires a section on strategies for implementation e.g. Play based, Inquiry based, Project based and problem based teaching and learning

A Holistic approach is to be used within the Foundation Phase and Science and Technology education should be integrated within.

Topics of the pre-service education programme should be aligned to the Foundation Phase curriculum documents (as a starting point).

Innovation and creativity should feature in the curriculum and pre-service and in-service teachers are to be engaged in these.

Contextual relevance and the implications for the lived realities of the pre-service and in-service teachers and their communities, to be considered and worked with.

Recommendation 6: Teacher education assessment of science and technology education

Application of content knowledge should be assessed through projects and practical investigations (Ubuntu Mapping should be used, as opposed to Bloom's taxonomy for significant learning

Micro-teaching lesson/s planning, presentations and reflections should be formally assessed

Further clarification on assessment:
For curriculum and assessment to be meaningful to the learner, it must invoke the curiosity of the learner and present real-life situations or examples of such to the learner for analysis. From the constructivist approach, teaching and learning do not happen in isolation; therefore, assessment should allow for communication and collaboration amongst learners. When communication and collaboration are catered for, then creativity and criticalness enter the process of learning. According to Vygotsky's socio-cultural theory of learning, learning depends on what individuals already know; new ideas occur as individuals adapt and change their old ideas; learning involves inventing ideas rather than mechanically accumulating a series of facts; meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas. Thus, assessment and learning opportunities should allow for assessment, include the use of case studies that allow the learners to express themselves, based on their context

Vygotsky (1978) defines the zone of proximal development (ZPD) as the distance between the actual developmental level determined by independent problem solving and the level of potential development as determined through problem solving in collaboration with more capable peers. Within a learning paradigm of social constructivism, interaction with more knowledgeable others (i.e. peers) is viewed as an effective way of developing skills and strategies through the provision of appropriate assistance (scaffolding).
Thus, the structuring of assessments should take on the form of more group work, authentic case studies, and relevant problem-orientated scenarios rather than a subject orientated approach. Assessments should inform the curriculum, within the constructs of digital practices and integrated assessment, the principles of humanness, care, respect, sharing, and compassion should be seen. The use of mobile technologies for assessment and its integration into the learning process for meaning making needs to be evident in the evaluation. Using mobile technologies, the evaluation tool should explore categories that ensure access to learning, as this influences success.

Recommendation 7: Adoption of the tables of content documented

We recommend that the TABLE of CONTENT in the documents be adopted and all suggested changes should be made, recognised and documented.

SUBJECT: Science

Matter and Materials Knowledge Strand

Big Ideas	Concepts	Topics	Expanding and deepening (KSVA)
✓ We can classify materials by their properties, in order to establish types and patterns. Properties determine the selection of materials for particular uses. ✓ We can modify materials in ways we choose, through our understanding of their substructure. ✓ All matter in the Universe is made of very small particles	Matter and chemical reactions. Mixtures; acid & bases; indicators; the periodic table	▪ Matter around us; matter - properties, types and uses; Metals and non-metals (uses); Mixtures; Solutions as special mixtures; Dissolving ▪ Particle model of matter , ▪ periodic table, ▪ Physical and chemical changes ▪ Reactions of metals with oxygen ▪ Reactions of non-metals with oxygen ▪ Acids & bases, and pH Value ▪	- NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. - Changing properties of chemicals and impacts in nature - Climate change

Energy and change Knowledge Strand

Big Ideas	Concepts	Topics	Expanding and deepening (KSVA)
✓ The total amount of energy in the Universe is always the same but can be transferred from one energy store to another during an event ✓ Energy is available from a limited number of sources, and the sustainable development of countries in our region depends on the wise use of energy sources.	Energy	Energy and energy transfer, energy arund us; energy and sound; stored energy in fuels; energy and electricity, electricity and movement and electric circuits, electrical conductors and insulators, mains electrici	- NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. Electricity applications

Life and living knowledge strand

Big Ideas	Concepts	Topics	Expanding and deepening (KSVA)
✓ Living things, including humans and invisibly small organisms, can be understood in terms of life processes, functional units and systems. ✓ Organisms in ecosystems are dependent for their survival on the presence of abiotic factors and on their relationship with other organisms. ✓ Organisms are organised on a cellular basis and have a finite life span	Matter- Living and non-living, hierarchical system of organisation, muscular & skeletons (locomotion); life processes and interacting with the environment;	▪ Living and non-living matter ▪ The cell ▪ Organisation of cells into systems ▪ Structures of plants and animals ▪ Animl skeletons ▪ Habitats of animals ▪ Plants and animals on earth ▪ What plants need to grow	NOS- Relevant knowledge to society, context, and IKS, pluralistic science -inventors and inventions. How do I fit.

✓ Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms	Plants, animals and ecosystems	▪ Life cycles ▪ Photosynthesis ▪ Nutrition ▪ Nutrients in foods ▪ Ecosystemss – food chains and food webs ▪ Flow of energy	

Earth and Beyond Knowledge Strand

Big Ideas	Concepts	Topics	Expanding and deepening (KSVA)
✓ Our planet is a small part of a vast solar system in an immense galaxy. ✓ The Earth is composed of materials which are continually being changed by forces on and under the surface. ✓ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate ✓ Our solar system is a very small part of one of billions of galaxies in the Universe	Solar systems	Planet earth(surface and fossils); the sun; the earth and the sun; movements of the earth and the planets; and the movment of the moon.	NOS- Relevant knowledge to society, context, and IKS, pluralistic science – discoveries

Recommendations for Intermediate Phase Teacher Education

Recommendation 1: The premise on which the teacher education curriculum is developed

What is the premise that the teacher education curriculum is developed on – the idea or theory on which the statement or action is based? This should be included in the preface to the curriculum document

Recommendation 2: Intermediate Phase (Humanities and Languages) teacher education programmes should include a compulsory module for science and technology education

All B.Ed. in Intermediate Phase (Humanities and Languages) should include a module on science and technology education
This recommendation should be written into the curriculum for teacher education (revised MRTEQ)
All Intermediate Phase Teaching programmes should have micro-teaching modules, which includes experiences for planning and presenting science and/or technology (engineering) lessons
The TABLES OF CONTENT developed shows only content, but there must be included in the programme, the practical investigations that underlie content.

Recommendation 3: Intermediate Phase (MSTE and Languages) teacher education programmes

All B.Ed. in Intermediate Phase Teaching (MSTE and Languages) programmes should include modules on science and technology education as stipulated in the teacher education curriculum (MRTEQ)
All intermediate phase teaching programmes (MSTE and Languages) should have micro-teaching which includes experiences for planning and presenting science and technology (engineering) lessons in all the strands for science and technology education
The TABLES OF CONTENT developed shows only content, but there must be included in the programme, the practical investigations that underlie content.

Recommendation 4: The formation of Communities in Practice to reflect and adapt the topics and content presented in the document.

The CONTENT TABLES have been developed from the Topics that are listed in the CAPS curriculum document and do not necessarily reflect current thinking on early science education.

The CONTENT TABLES developed shows only content. The practical investigations that underlie the content should also be included.
The content column "expanding and deepening" (KSVA) e.g. Nature of Science, intuitive knowledge, IKS etc should be integrated in the topics and not as stand alone ideas

Topics listed should be extended to include relevant, contextual issues as part of case studies. An example of this is the topic on Healthy Living - currently the outbreak of measles – what does this mean in the lives of the children?

It is recommended that Communities in Practice are formed for the ECE, foundation phase and intermediate phase for science teacher education, made up of all HEIs. These communities in practice will reflect on the implementations of these science education modules and adapt the current tables of content as given here through these reflective practices.

Recommendation 5: Recommendations for furhter consideration on the CONTENT TABLES documents (page 7-11 of the document)

The document requires a section on strategies for implementation e.g. Inquiry based, Project based and problem based teaching and learning

A Holistic approach is to be used within the Intermediate Phase and Science and Technology education should be integrated within.

Topics of the pre-service education programme should be aligned to the Intermediate Phase curriculum documents (as a starting point).

Innovation and creativity should feature in the curriculum and pre-service and in-service teachers are to be engaged in these.

Contextual relevance and the implications for the lived realities of the pre-service and in-service teachers and their communities, to be considered and worked with.

Recommendation 6: Teacher education assessment of science and technology education

Application of content knowledge should be assessed through projects and practical investigations (Ubuntu Mapping should be used, as opposed to Bloom's taxonomy for significant learning

Micro-teaching lesson/s planning, presentations and reflections should be formally assessed

Further clarification on assessment:

For curriculum and assessment to be meaningful to the learner, it must invoke the curiosity of the learner and present real-life situations or examples of such to the learner for analysis. From the constructivist approach, teaching and learning do not happen in isolation; therefore, assessment should allow for communication and collaboration amongst learners. When communication and collaboration are catered for, then creativity and criticalness enter the process of learning. According to Vygotsky's socio-cultural theory of learning, learning depends on what individuals already know; new ideas occur as individuals adapt and change their old ideas; learning involves inventing ideas rather than mechanically accumulating a series of facts;

meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas. Thus, assessment and learning opportunities should allow for assessment, include the use of case studies that allow the learners to express themselves, based on their context

Vygotsky (1978) defines the zone of proximal development (ZPD) as the distance between the actual developmental level determined by independent problem solving and the level of potential development as determined through problem solving in collaboration with more capable peers. Within a learning paradigm of social constructivism, interaction with more knowledgeable others (i.e. peers) is viewed as an effective way of developing skills and strategies through the provision of appropriate assistance (scaffolding).

Thus, the structuring of assessments should take on the form of more group work, authentic case studies, and relevant problem-orientated scenarios rather than a subject orientated approach. Assessments should inform the curriculum, within the constructs of digital practices and integrated assessment, the principles of humanness, care, respect, sharing, and compassion should be seen. The use of mobile technologies for assessment and its integration into the learning process for meaning making needs to be evident in the evaluation. Using mobile technologies, the evaluation tool should explore categories that ensure access to learning, as this influences success.

Recommendation 7: Adoption of the tables of content documented

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Maths and Science Standing Committee
PRESERVICE TEACHER EDUCATION

SCIENCE SENIOR PHASE

SUBJECT: **Natural Science**
PHASE: **Senior Phase**

The Natural Sciences content should be transformed, decolonised, Africanised and enable student teachers to:

- develop Scientific skills and processes / habits of mind
- intergrate and appreciate indigenous knowledge systems
- Intergrate the development of innovative skills and application
- Have a solid and holistic understanding of the big ideas in science. This entails the identification of appropriate science big ideas, and the inclusion of advanced science content to supplement the existing SN CAPS natural science content, in order to enhance students' ability to understand relationships between and within the big ideas
- Understand the transitions involved, such as moving from; Inductive to deductive reasoning; informal to formal descriptions, theory to practice/applications/ concrete concepts; familiar to unfamiliar ideas; and macroscopic to microscopic levels of matter and change, etc.

Notes for feedback:

1. We decided to group the big ideas per concept to accommodate for the extension & expansion.
2. We felt the idea of subject groups was beneficial and enriched the content as perceived by the 'subject specialist'; all subject groups did well by expanding more on concepts
3. To improve readability, we decided to bullet columns

4. We felt that where there is only a single item relating to a big idea, we had to provide justification for it as a comment. Otherwise the big idea might seem irrelevant by glancing over the table

SENIOR PHASE

Life and Living Strand (From Life Sciences)

Big Idea	**Concepts**	**Topics**	**Extension and Expansion teacher content**
▪ Organisms are organised on a cellular basis. ▪ Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms. ▪ Genetic information is passed down from one generation of organisms to another. ▪ The diversity of organisms, living and extinct, is the result of evolution.	Cells as the basic unit of life	– Microscopy – Cell structure and function (organelles); – Cell differentiation and specialization; – Cells in tissues, organs and systems – Classification of cells	– Biochemistry: micro & macro-molecules and organic & inorganic compounds with relevance to life – Biotechnology with relevance to life; – Nature and History of phenomena, – IKS and Sustainable Development/Living issues in Science; – Relevancy to the society (decolonization, contextualization) – Pluralistic Science – Inventions and Inventors; – Discoveries and discoverers

▪ Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.	Bio-energetics	– Life processes in a cell (all) (respiration, excretion, irritability[sensitivity and response], growth, reproduction, movement, nutrition) – Photosynthesis and Respiration – Endergonic and exergonic processes	– Application of Life Processes; – Nature and History of phenomena, – IKS and Sustainable Development/Living issues in Science; – Relevancy to the society (decolonization, contextualization) – Pluralistic Science – Inventions and Inventors; – Discoveries and discoverers
▪ Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms. ▪ The diversity of organisms, living and extinct, is the result of evolution.	Interactions and inter-dependence in the environment	– Ecosystems and Ecological inter-relationships; – Biosphere, Biomes – Food chains and food webs – Energy flow – Balance in an Ecosystem – Adaptations	– Conservation; – Human-environment relationships (biodiversity, e.g. Millennium eco-system assessment); – Nature and History of phenomena, – IKS and Sustainable Development/Living issues in Science; – Relevancy to the society (decolonization, contextualization) – Pluralistic Science – Inventions and Inventors; – Discoveries and discoverers
▪ Organisms are organised on a cellular basis.	Systems in a human body	▪ Circulatory and respiratory systems ▪ Digestive system	– Nature and History of phenomena,

▪ Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms. ▪ The diversity of organisms, living and extinct, is the result of evolution.		▪ Human reproduction	− IKS and Sustainable Development/Living issues in Science; − Relevancy to the society (decolonization, contextualization) − Pluralistic Science – Inventions and Inventors; − Discoveries and discoverers
▪ Organisms are organised on a cellular basis. ▪ Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms. ▪ Genetic information is passed down from one generation of organisms to another. ▪ The diversity of organisms, living and extinct, is the result of evolution.	Biodiversity and Variation of species	− Classification (micro and macroscopic) − Natural selection − Basics of genetics	− Nature and History of phenomena, − IKS and Sustainable Development/Living issues in Science; − Relevancy to the society (decolonization, contextualization) − Pluralistic Science – Inventions and Inventors; − Discoveries and discoverers

SENIOR PHASE
Energy and change (from Physics group)

Big Idea	Concepts	Topics	Extension and Expansion teacher content
▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires a net force to be acting on it.	Matter, particles and molecules	− Particulate nature of matter − States of matter − The atom − Molecules −	- Kinetic molecular theory

▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.			
▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires a net force to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Energy, conservation and systems	– Sources of energy – Potential and Kinetic Energy – Heat transfer, Insulation and energy saving – Energy transfer to surroundings	- Principles of thermodynamics - Work energy theorem - Indigenous knowledge such as food preservation - System as a concept - Thermally closed versus open system
▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires a net force to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Electricity	– Static electricity – Energy transfer in electrical systems – Electric cells as energy systems – Resistance – Series and parallel circuits – Safety with electricity – Energy and the national electricity grid – The national electricity supply system – Cost of electrical power	- The national energy grid and social issues - Faraday's law - Potential difference - Ohms' Law - Kirchhoff's law - EMF - Circuits - Solar, nuclear, wind, coal
▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Waves and Light	– Visible light	- Dual nature of light - Electromagnetic spectrum - Other types and media of waves

▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires a net force to be acting on it.	Force	− Forces – contact and distant forces − Effects of forces − Resultant forces	- Force and motion (Laws) - Kinematics - Magnetism

SCIENCE SENIOR PHASE
Matter and Materials Knowledge Strand (From Chemistry)

Big Ideas	**Concepts**	**Topics**	**Expanding and deepening**
▪ All material in the Universe is made of very small particles.	Mixtures	− Separating mixtures	- Homogenous & heterogeneous mixtures - Different methods of separating mixtures
▪ All material in the Universe is made of very small particles.	Acids, neutrals and bases	− Acids, bases and neutrals − Acids & bases, and pH Value	-
▪ All material in the Universe is made of very small particles.	Periodic table	− Introduction to the Periodic Table of Elements	- Metals; semi-metals / metalloids & non-metals
▪ All material in the Universe is made of very small particles. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen. ▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	Properties of materials and chemical reactions	− Properties of materials − Atoms − Particle model of matter − Physical and chemical changes − Compounds − Reactions of metals with oxygen − Reactions of non-metals with oxygen − Reactions of acids with bases: Part I − Reactions of acids with bases: Part II	- Atomic theory - Principles of Chemical bonding - Chemical reactions and their impacts - Rates of chemical reaction - Density and pressure - Relevancy to the society (decolonization, contextualization) - Organic and inorganic compounds - Intermolecular forces - Strengthening of bonds

		− Reactions of acids with bases: Part III − Reactions of acids with Metals	- Changing properties of chemicals and impacts in nature - Subatomic particles - Climate change (environmental effects) - Indigenous knowledges such as brewing and making dwellings

Planet Earth and Beyond (From Chemistry)

Big Ideas	Concepts	Topics	Expanding and deepening
	Astronomical relationships	▪ Refer to physics subject table at the bottom	▪
▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate. ▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires unbalanced forces to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Earth	− The Earth as a system • Atmosphere • Lithosphere • Hydrosphere • Biosphere	− Earth as a habitable planet − Habituation of Mars − Continental drifts − Climate change − Climatic change − Indigenous knowledges such as Management of soil and water
	Relationship between the earth, moon and the sun	▪ Refer to physics subject table at the bottom	▪
▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	Mining	▪ Mining of mineral resources	▪ Effects of mining ▪ Indigenous knowledges such as iron smelting

Big Ideas	Concepts	Topics	Expanding and deepening
▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires a net force to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen. ▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate. ▪ The solar system is a very small part of one of millions of galaxies in the Universe.	Astronomical relationships	▪ Solar system and beyond	- Looking into space - Birth, life and death of stars - Cosmology - Satellites - Relevancy to the society (decolonization, contextualization) ▪ Indigenous knowledge such as understanding astronomy (extraction, direction, etc.)
▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate. ▪ Objects can affect other objects at a distance. ▪ Changing the movement of an object requires unbalanced forces to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Earth	− The Earth as a system • Atmosphere • Lithosphere	− Earth as a habitable planet − Habituation of Mars − Hydrosphere − Climate change − Continental drifts − Climatic change − Indigenous knowledge such as Management of soil and water
▪ Objects can affect other objects at a distance.	Relationship between the Earth, Moon and the Sun	▪ Relationship of the Sun to the Earth ▪ Relationship of the Moon to the Earth	▪ Gravity ▪ Force ▪ Magnetic fields ▪ Solar radiation ▪ Basics of electrostatics

▪ Changing the movement of an object requires a net force to be acting on it. ▪ The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen. ▪ The solar system is a very small part of one of millions of galaxies in the Universe.			▪ Indigenous knowledge such as understanding astronomy (direction, seasons, etc.)
▪ The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	Mining	▪ Mining of mineral resources	▪ Effects of mining ▪ Indigenous knowledge such as iron smelting

Recommendations

PREFACE:

- **Inquiry Methods:** Advocate training of teachers using inquiry-based teaching and learning approaches – so they can experience active learning that encourages learners to ask questions, conduct research, and explore new ideas. This approach helps learners develop critical thinking, problem-solving, and research skills, which are part of 21st century skills.
- **ICT & digital literacy:** Advocate integration of ICT/digital literacy in teacher training and teaching approaches, which is also part of 21st century skills.
- **New Developments:** Make more explicit the importance of educating our student teachers about keeping staying informed about new developments in science even regarding aspects not formally taught as part of the curriculum.
- **Integration of strands:** The four Science strands (i.e., Life & Living, Matter & Materials, Energy & Change, Planet Earth & Beyond, and their relevant Technology aspects) are laid out separately on the document, but it should be made explicit that the different strands should be integrated with one another as often as possible, to dispel compartmentalised and/or de-contextualised learning.

CONCEPTS & CONTENT:

- **Addressing Sensitive or Controversial Topics:** Advocate objective and inclusive teaching approaches, particularly with certain sensitive topics e.g., evolution
- **Climate Smart ways of living vs climate change:** Under Matter and Materials, the term climate change is used as traditionally used. We advocate for the use of the expression ‘Climate smart ways of living’ as this makes the concept more contextualized and not just factual – ‘climate smart ways of living’ insinuates ‘what one can do’.

GENERAL COMMENTS & RECOMMENDATIONS:

- Teachers to teach in their area of specialization or development.
- Workshop for in-service teachers to be more thorough and in-depth, not just quick.
- Construct a supporting document of effective teaching approaches.
- Unhide the ‘hidden curriculum’ – teach aspects like ‘Ubuntu’ integrated with the science curriculum.
- There’s consensus that Astronomy concepts are currently not thorough enough in the Natural Sciences (NS)

SUBJECT: Science

FET Chemistry			
Matter and materials			
Big Ideas	**Concepts**	**Topics**	**Expanding and deepening**
All material in the Universe is made of very small particles. Objects can affect other objects at a distance. Changing the movement of an object requires unbalanced forces to be acting on it. The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	Properties of materials and chemical reactions	Materials, heterogeneous and homogeneous mixtures, pure substances, names and formulas, metals and non-metals, electrical and thermal conductors and insulators, magnetic and non-magnetic materials	
	Matter and classification	Particle theory of matter	Particles and matter
	States of matter; atomic structure; kinetic molecular theory; wave-particle duality	Models of the atom, atomic mass and diameter, protons, neutrons and electrons, isotopes, energy, quantization and electron configuration, mass and charge and occupying volume as three	Nanotechnology, subatomic models

		properties of matter, charged particles and e/m ratio, effects of e/m fields, ionization, atoms and light, wave-particle duality, Bohr atom and spectroscopy	
	Periodic table	Periodic table: position of the elements (names of groups etc.), similarities in chemical properties in groups, electron configuration in groups	Periodic trends (e.g. ionic size, etc), more knowledge of the d block in the periodic table - how far do we go?
	Chemical bonding	Covalent bonding, ionic bonding, metallic bonding	Principles of Chemical bonding Hybridization
	Substances are made of:	Atoms and compounds, molecular substances and ionic substances	
	Molecular structure	Chemical bonds and molecular shapes, electronegativity and bond polarity, bond energy and bond length	
	Gases	Motion and kinetic (molecular) theory of gases, gas laws, ideal and real gases, relationship between T and P	Historical perspective Density and pressure
	Intermolecular forces	Chemical bonds revised, types of intermolecular forces, states of matter , three phases of water (relate macroscopic props to sub-micro structure), density [link to molecular shape], kinetic energy and temperature (link to kinetic theory of gases)	Interactions - gravitational, electromagnetic, contact, dispersive, frictional, forces; (chemical) atomic, molecular, bonds, reactions, intermolecular forces
	Organic chemistry	Functional groups, saturated and unsaturated structures, physical properties, isomers, naming and formulae, chemical reactions (substitution, addition and elimination)	Link with Life & living

	Organic macromolecules	Plastics, polymers	
Chemical Change			
All material in the Universe is made of very small particles. Objects can affect other objects at a distance. . The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Physical and chemical	Separation by physical means, separation by chemical means, conservation of atoms and mass, law of constant composition	Separation by physical means, separation by chemical means, conservation of atoms and mass, law of constant composition
Changing the movement of an object requires unbalanced forces to be acting on it.	Representing chemical change	Balanced chemical equations	
The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Mole concept	Atomic mass units, stoichiometry Molar volume of gases (related to balanced equations), concentration, limiting reagents, volume relationships in gaseous reactions	
The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate	Reactions in aqueous solution	Ions in aqueous solutions, ion interaction, electrolytes, conductivity, precipitation, chemical reaction types	
	Energy and chemical change	Energy changes related to bond energy, exothermic and endothermic reactions, activation energy Thermodynamics and its nature	Maxwell and Boltzmann and the mathematical beginnings of (statistical) thermodynamics Thermodynamics; the physics of the very small and very many Systems – thermodynamics, state functions (S, G, H, K) Entropy and Gibbs Free Energy
	Types of reactions	Various types of reactions e.g. neutralization, decomposition, substitution, ion exchange, precipitation, redox reactions, etc	

	Reaction rate	Factors affecting rate, Maxwell-Boltzmann distributions, measuring rate, mechanism of reaction and of catalysis	Chemical kinetics, Order of reactions, half-life, rate constant, average rate, instantaneous rate, integrated rate laws, conservation & non-conservation of energy Chemical reactions and their impacts
	Chemical equilibrium	Factors affecting equilibrium, equilibrium constant, application of equilibrium principles	Solubility product, Kc, Kp, Gibbs Energy
	Acids and bases	Reactions, titrations, pH, salt hydrolysis	Buffer systems, introduction to analytical chemistry
	Electrochemical reactions	Electrolytic and galvanic cells, relation of current and potential to rate and equilibrium, standard electrode potentials, oxidation numbers, oxidation and reduction half reaction and cell reactions, application of redox reactions	Anodic and cathodic protection of metals
CHEMISTRY: CHEMICAL SYSTEMS			
Matter and materials			
All material in the Universe is made of very small particles. Objects can affect other objects at a distance. Changing the movement of an object requires unbalanced forces to be acting on it. The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Hydrosphere	Composition of the hydrosphere, interaction with other global systems, overview of its interaction with the atmosphere, lithosphere and biosphere, water moves through air (atmosphere), rocks and soil (lithosphere) plants and animals (biosphere); by dissolving and depositing, cooling and warming, how building dams affects the lives of the people and regional ecology	Chemistry and food industry - links to health issues. Pharmaceutical industry, traditional medicine, reverse osmosis as way of purifying water, carbon emissions (sustainable forms of energy
The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.	Lithosphere	Mining, energy resources	Green chemistry - linked to micro-chemistry, and finding alternatives (e.g. taking lead out of petrol), in labs using alternative

			chemicals which are everyday - less impactful (e.g. stopping using asbestos, mercury, benzene)
	Chemical industry	Fertilizer industry, examples of redox reactions and application of oxidation numbers including Haber process, contact process, Ostwald process, nitrogen content of compounds, plant nutrients and eutrophication, fertilizer proportions	Case studies beyond gold and iron (e.g. detergents, traditional brewing, cosmetics, …) Relevant local cases. Experiential activities such as soap, toothpaste, umqombothi, sour dough bread …

Mechanics			
Big Ideas	**Concepts**	**Topics**	**Expanding and deepening**
Changing the movement of an object requires unbalanced forces to be acting on it.	Frame of reference, kinematics, position, displacement, distance, average speed and philosophy, instantaneous speed and velocity, acceleration, vector diagrams, description of motion in words, kinematic equations of motion, graphs of motion	Kinematics	2 dimensional motion, projectile and circular motions Basic special relativity
	Resultant of two vectors at an angle and perpendicular vectors, resolution of a vector into (rectangle/parallel & perpendicular) components	Vectors	Vectors in two dimensions
	Vertical projectile motion in one dimension represented in word, diagrams, equations and graphs	Projectile motion	Effect of air resistance (force α square of velocity), terminal velocity, viscosity and Stoke's Law Projectile motion in two dimensions (Newton's first applies horizontally; Newton's second law applies vertically)
	Newton's first law, Newton's second law, Newton's third law,	Forces	Statics, analysis of structures, moment of a force, scaffolding,

	Newton's law of universal gravitation. Different kinds of forces (push, pull), weight, normal force, frictional force, tension (strings and cables), force diagrams, free body diagrams		buildings, indigenous structures, curves in arches & vaulting Newton's laws applied to road safety, structure of buildings, domestic situations & sport Origin of the universe; indigenous/ancient cosmologies; modern, scientific, cosmological theory; big bang and origins of physics & chemistry; general relativity, birth & death of stars & galaxies, light and special- & general relativity, gravitational lensing, astronomical examples & calculations Rotational dynamics, projectiles in 2D Buckminster Fuller and geodesics (cf "buckyballs" and graphene under molecular structure)
	Momentum, Newton's second law expressed as f(p), impulse (& change of momentum), elastic & inelastic collisions, conservation of linear momentum (in one dimension)	Momentum and impulse	Conservation of linear momentum (in two dimensions)
The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Gravitational potential energy, kinetic energy, mechanical energy, conservation of mechanical energy (in absence of dissipative forces) Work, conservation of energy with non-conservative forces present, work-energy theorem, power	Work, Energy and power	Integrate scientific values and attitudes including curiosity; precision and attention to detail; scepticism; positive attitudes to failure; respect for evidence; appreciation of good, evidence-based decisions; alertness to ambiguity etc.

			Derivation of kinematics and dynamics formulae. Lenz's law – show that it is a form energy conservation
	Pulses & amplitude, superposition(of pulses) Wavelength & amplitude, frequency & period, wave speed (v = fλ) Sound waves, pitch, loudness, quality (tone), ultrasound	Waves, sound & light	Tsunami as a pulse; causes of tsunamis Seek opportunities for gaining practical experience of pulses & waves
	Nature of electromagnetic (EM) radiation, EM spectrum, dual nature of EM as particle & wave nature, energy of the photon related to frequency & wavelength ($C = f\lambda$)	Electromagnetic radiation	Communications, cell phones, microwave radiation (dangers & opportunities), roll out of optical fibre networks in SA Lasers & laser technology, fibre-optics, optical instruments Medical applications & EM radiation in the health sector, scanning instruments (including ultrasound, PET & NMR) Invisibility by matching of refractive indices (e.g. the "invisibility cloak"!)
	Refraction, Snell's Law, critical angle & total internal reflection Huygens' wave fronts, diffraction & interference Doppler effect in relation to sound & ultrasound; for either moving source or moving observer; explanation of red- and blue- shift for light from moving stars	Geometrical optics Doppler effect of sound and light	Optometric instruments, correction of vision Interference and non-reflective coatings, link to SKA and VLBI Integrate scientific values and attitudes including curiosity; precision and attention to detail; scepticism; positive attitudes to failure; respect for evidence; appreciation of good, evidence-based decisions; alertness to ambiguity etc.

Objects can affect other objects at a distance.	Magnetic field of permanent magnets, poles of permanent magnets, attraction and repulsion, magnetic field lines, Earth's magnetic field, the compass	Electricity and Magnetism Electrostatics Electrodynamics	Aurora effects, communication systems Lightening Industrial applications Magnetic fields in the solar system
	Two kinds of charge, force exerted by charges on each other (descriptive), attraction between charged & uncharged objects (polarisation), conservation of charge, quantization of charge.	Positive and negative charges Attraction and repulsion Total electric charge in an isolated system	Field around a point charge
	Coulomb's law, electric field	Inverse square law of electric charges	Relate to gravity
	Magnetic field associated with current-carrying wires, Faraday's law Electrical machines (generators, motors), alternating current	Magnetic effect of current in a wire Magnetic effect of current in a coil Magnetic force Electromagnetic induction AC and DC electrical supplies The bicycle dynamo Rectifier Car alternator Moving coil meter	Lenz's law Transformer Mutual inductance
	EMF, potential difference (pd), current, measurement of voltage (pd) and current, resistance, resistors, series and parallel connections Ohm's Law, energy and power	Symbols of electrical components of circuits Practical electrical circuits	Band theory, Kirchoff's rules, Hall effect, Earth protected from solar radiation by its magnetic field, magnetic fields of other planets Energy generation and collection, alternative energy production

	Internal resistance, series-parallel networ ks (through circuit problems)		(solar, wind, nuclear), SA energy needs into the future, the induction stove and other everyday energy-saving devices, medical technologies: pacemakers, defibrillators, computer-aided tomography (CAT) and Alan Cormack's 1979 Nobel Prize, cell phone, power banks … Electronic components, diodes, transistors, capacitors, rectifiers
All material in the Universe is made of very small particles.	Materials, heterogeneous and homogeneous mixtures, pure substances, names and formulae, metals and , non-metals, electrical and thermal conductors and insulators, magnetic and nonmagnetic materials.	Matter and materials Atomic and molecular structure of materials Properties of matter and materials	Nanoscience, sub-atomic models Periodic trends in addition to Grade 9 trends (e.g. ionic size, etc.), more knowledge of the d-block in the periodic table …
The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Photo-electric effect, emission and absorption spectra	Light as a particle and wave Light and electricity relationship Interaction between light and matter	History of Einstein's Nobel prize Quantum theory Hertz and Lenard work on photo electric effect
The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.	Heat and temperature Heat transfer mechanisms Heat capacity, specific heat capacity and latent heat Internal energy, Thermal equilibrium Laws of thermodynamics	Heat and heat transfer, changes of state Thermodynamics	Heat engines Heat pumps Application: heat engines & heat pumps Entropy

Life Sciences: FET
PRE-SERVICE TEACHER EDUCATION
LIFE SCIENCES
Principles to be considered:

1. Use the Curriculum as the base and include emergent aspects, to be included in the Big Ideas
2. Four Big Ideas [1. Evolution; 2. Interactions; 3. Energy and Communication – cellular processes; 4. Genetics and information transfer][1] and nine central aspects (see below)
3. The Natural Sciences/Life Sciences content should be transformed, decolonised and Africanised
4. Nature and History of Science, IKS and Sustainable Development/Living to be integrated across the Four Big Ideas
5. Integrate the affective domain
6. Inquiry-based approach should be used
7. Develop Scientific skills and processes
8. Integrate the development of 21st Century skills
9. Understand the transitions involved, such as moving from inductive to deductive reasoning; informal to formal descriptions; theory to practice/applications/concrete concepts; familiar to unfamiliar ideas; macroscopic to microscopic levels of matter and change
10. Overarching integration of learners' intuitive knowledge and understanding – how does it move? how does it change, where does it fit, how does it fit?
11. Most major biological concepts fall under more than one big idea. Teachers should be able to work with this and demonstrate this within the respective curricular content
12. Consider the integration of Technology (Applied Science) to be integrated into the Foundation Phase and Intermediate Phase

Challenge linked to Schooling:

Grade 7 in the Primary School and Grade 8 in the High/Secondary School. There is a lack of continuity between Grade 7 and 8. MRTEQ policy imperative - Intermediate pre-service teachers should be prepared to teach Grade 7, as well.

Nine Central Aspects

1. Form fits function/function fits form;
2. Cellular basis of life;
3. Hierarchical systems of organization – Organisation of matter;
4. Energy and Life;
5. Heredity and reproduction
6. Interactions with the environment - Sustainability
7. Homeostasis;
8. Evolution and adaptation;
9. Interdependency, unity and diversity of life

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[1] See Appendix for the details re Big Ideas

BIG IDEAS	Concepts	Topics	EXTENSION AND EXPANSION (From Mader & Windelspecht: 2013)
~~**Evolution**~~ The diversity of organisms, living and extinct, is the result of evolution.	Diversity and continuity of life (prokaryotes, animals and plants) Natural selection (Darwin) and Adaptation Unity	*Biodiversity and Classification* -Microbiology and Evolution (viruses, bacteria, Archaea, Protists and Fungi) -Plants -Animals History of Life Darwinism and Natural Selection Human Evolution	Darwin and Evolution How Populations evolve Speciation and Macroevolution Origin and History of Life Taxonomy, systematics and phylogeny Plant Evolution and Diversity Animal Evolution and Diversity (Invertebrate, Vertebrate and Human) Behavioural Ecology
~~**Interactions**~~ Biological systems interact, and these systems and their interactions possess complex properties. ~~Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.~~	Biological levels of organisation Biological Systems interact and are interdependent Energy flow	Plant and Animal Tissues Support and Transport Systems in Plants Reproduction in plants Support Systems in Animals Transport systems in Mammals Animal Nutrition Gaseous exchange Excretion Reproduction in vertebrates Human Reproduction Nervous System Senses	*Plant Biology* Flowering Plants: Structure and Organisation Flowering Plants: Nutrition and Transport Flowering Plants: Control of growth responses Flowering Plants: Reproduction *Comparative Animal Biology* Animal organisation Circulation and Cardiovascular systems The Lymphatic and Immune Systems

		Endocrine System Population Ecology Biosphere to Ecosystems Human Impact on the Environment- Current crises (Climate Change, Biodiversity Loss)	Digestive Systems and Nutrition Respiratory Systems Body fluid regulation and Excretory Systems Neurons and Nervous Systems Sense organs Locomotion and Support Systems Hormones and Endocrine Systems Reproductive Systems Animal Development and Aging Population Ecology Community and Ecosystem Ecology Major Ecosystems of the Biosphere (including marine ecology) Conservation of Biodiversity Climate Change – mitigation,adaptation, resilence
~~**Energy, biochemical processes and Communication**~~ Biological systems utilize free energy and molecular building blocks to grow, to reproduce,	Chemistry of life (Molecular building blocks) Cellular communication Energy to support life (photosynthesis and cellular respiration)	Homeostasis Chemistry of Life -Inorganic compounds -Organic compounds The cell unit of life Energy transformations to support life- Photosynthesis	Basic Chemistry The Chemistry of Organic Molecules Cell Structure and Function Membrane Structure and Function

and to maintain dynamic homeostasis.	Biological systems maintain homeostasis	Energy transformations-Cellular Respiration Plant movements	Metabolism: Energy and Enzymes Photosynthesis: concepts related to light (electromagnetic spectrum, photons, energy release)- structure of chloroplasts, functions, adaptations - light dependent and carbon fixation reactions of photosynthesis - reactions in Photosystem I and Photosystem II - carbon fixation reactions-metabolic diversity Cellular Respiration e.g. aerobic and anaerobic respiration and fermentation Aerobic respiration: reactions of glycolysis, formation of acetyl coenzyme A, citric acid cycle, electron transport and chemiosmosis - reactions of anaerobic respiration and fermentation Homeostasis: eg's Excretion and osmoregulation in the animal kingdom Thermoregulation Tropisms
Genetic information is passed down from generation to generation.	Basics of cellular reproduction Patterns of Inheritance Molecular Genetics	DNA code of life Cell Division (Mitosis) Cell Division (Meiosis) RNA and Protein Synthesis	Genetic Basis of Life -The Cell cycle and cellular reproduction

			- Meiosis and Sexual Reproduction - Mendelian Patterns of Inheritance - Molecular Biology of the Gene - Regulation of Gene Expression - Biotechnology and Genomics

Recommendations

Recommendations for the FET BEd Physical Sciences and Life Sciences preservice teacher curriculum

The committee makes the following recommendations based on the developed curriculum document for the preparation of Physical and Life Sciences preservice teachers in specific subject matter in science.

1. The developed content coverage for the curriculum document is aimed at making available Physical and Life Sciences disciplinary content knowledge for secondary school teachers. This is a way of avoiding having the preservice teachers take generic science courses that are not fit-for-purpose. This concept is not new since the same is applied to the preparation of other professionals such as engineers where they take courses such as chemistry for engineers.
2. Based on the above point, we recommend the adoption of the fit-for-purpose content coverage science education curriculum as a common policy document for all universities in the country involved in Initial Teacher Education programmes. The adoption of the curriculum document will ensure that the Physical and Life Sciences teachers are prepared with sufficient content mastery to teach the school science curriculum with deeper conceptual understanding and insights. The adoption of the curriculum document will also ensure uniformity in the way preservice teachers are prepared across the country.

3. The Physical and Life Sciences content coverage is recommended pitched at NQF level 5/6/7 as recommended by MRTEQ document so that the content mastery is slightly above the mastery that can be acquired from the school curriculum and other qualifications lower than the Bachelor of Education. This is important because it is from this pool of graduates that the country will source the future science teacher lecturers and educators.
4. One of the strategies in implementing this science preservice teacher preparation curriculum is the adoption of the "Faculty of Education" or "School of Education" or similar model which incorporates the offering of specific science subject matter, in addition to the offering of education subjects including, its foundations. The outsourcing of specific science subjects to other faculties is not recommended for several reasons such as the lack of pedagogy and conceptual development, the lack of alignment of school CAPS curriculum and minimal teaching practice etc. This strategy is important to support the notion of "science for secondary school teachers" and takes into cognizance that a BEd is a professional qualification, therefore the lecturers must also have relevant science subject specialization as well as education qualifications.
5. In cases where the teaching of the Physical and Life Sciences are outsourced to other faculties due to the way in which resources are allocated, these faculties must be engaged with the education faculties to make sure that the courses offered are in line with the recommended curriculum and that the lecturers who teach the preservice teachers have a qualification in education.

GLOSSARY

Extension: In ITE, certain content areas should be extended beyond school learners formal requirements.
Expansion: Advanced content for the education of the teacher, takes a key concept further than is required by CAPS and thus broadens the teachers knowledge.

ADDENDUM

Addendum 1: GLOSSARY

Curriculum content
The content of the curriculum should be set out systematically, in detail and in a familiar format. To this end the most obvious layout to use is the CAPS, FET curriculum.

CAPS topics
CAPS topics and their description provide the framework for what teacher trainers must teach because it describes what FET Phase teachers must be trained to teach. As a consequence, a curriculum for ITE will originate in the CAPS curriculum. As curriculum changes are promulgated, so the ITE curriculum will also be modified accordingly. The detailed notes in the CAPS document also contain what are called “expansions” and “extensions” here. See below.

Key concepts
The framework of key concepts (which, in a sense, is one kind of big idea) is an important guideline for trainers and trainees. Key concepts are generally taken from the canon of science and therefore form a familiar framework. The inter-relation of key concepts and the links and associations between and among key concepts should become familiar to intending teachers.

Extensions
In ITE, certain content areas or key concepts or topics should be extended beyond school learners’ formal requirements so that teachers will have a broader, perspective on the content they must teach. Extensions are the answers to the question: “what/where does this topic lead to?” and “what are the societal implications of this work?” The extension broadens knowledge and perspectives for the teacher beyond the (CAPS) requirements for learners. Extensions can include contemporary issues and trends such as transformation, redress, mullti-culturalism and indigenous knowledge systems.

Big ideas
The nuanced notion of the “big idea” is discussed in detail in Addendum 2.

Curricular expansions
The “expansion” differs from the “extension” in that, whereas the latter relates to advanced content for the education of the teacher (in training), an expansion either (a) takes a key concept further than is required by CAPS and thus broadens the teacher’s knowledge; or (b) is used specifically to show practical applications of a scientific idea to technology or environmental issues etc. An expansion is the “extra” that a teacher can provide for the interest and benefit of learners, especially more able learners (e.g. showing how of equations of linear motion can be derived). Expansions can be topics that themselves link distinctly different content topics or key concepts in surprising ways e.g. gravitational lensing.

Role of mathematics
A case can be made for building trainee teachers' appreciation of the role that mathematics has played in the development of modern science. The questions on which such a case is based can be found in Addendum 3. Mathematical advances have been closely related to the history and advance of science and are therefore integral both to appreciating the history of science and understanding the nature of science. Of particular interest is the fact that various branches of mathematics have been developed first as purely abstract constructions and have later been applied to explanations (theories) of natural systems.
History of science
A case for building trainee teachers' appreciation of the history of science and the special role of mathematical physics is made in Addendum 4. Trainee teachers, with the work they do in their training course, should be able to read with understanding accounts in the history of science. This self-study must begin to build teachers' own frameworks from which to appreciate and understanding the development of the scientific enterprise as an intensely human activity. And they should develop the will, confidence and enthusiasm to pursue such efforts independently.
Process skills
Teachers in training must be exposed to various ways of teaching and to practical pedagogy. This is not done merely through direct instruction but by practical exposure to appropriate pedagogies as demonstrated through the teaching methods of the teacher trainers. The aim of this learning must be the development of trainee teachers' own skills in the processes of science e.g. observation, recording, data processing, classification etc. Guidelines for minimum, generic, process skills can be found in CAPS for the Physical Sciences (DBE, 2011; pp 158-159). At an advanced level, skills will include mathematical, communicative, scientific reasoning and improvisational data logging and modelling skills; and the ability to carry out simulations and integrate ICTs.
Habits of mind
This term is dealt with in detail in the Foundation Phase document. Important "habits of mind" for science and mathematics learning are formed in the early years of education and preface the ability to learn effectively throughout a learner's education which, it is hoped, will be life-long. In sum, well-developed habits of mind make up that set of behaviours that broadly define the condition of "being educated" (see Addendum 5). Thus "habits of mind" can be seen to include skills in science as well as values. Values in science, which must be as focus of ITE for science teachers, include integrity; respect for evidence, respect for the views of others and an ability to collaborate.
Study habits
It is impossible to be taught everything one needs to know by others. Therefore education must involve the imparting or development of individual study habits, especially the ability and willingness to learn independently. These habits must be developed through the school years. Their development is influenced by pedagogy.

Addendum 2: BIG IDEAS

Thomas Kuhn describes early twentieth century science as having undergone a "paradigm shift" comparable to the "Copernican Revolution". A paradigm in science combines all of *world-view and "ways of seeing"* (e.g. the "ecological" view of the inter-relatedness of things); *scientific patterns of thought and "habits of mind"* (e.g. respect for "scientific" evidence and conceptual rigour); *methods of science* (e.g. hypothesis testing and "conjecture and refutation"); and *the body of scientific theory* used to make sense of the natural world and universe. These are all "big ideas" in science.

Also "big ideas" are words and expressions describing scientific ideas and principles which have been (accurately) imported into everyday discourse and explanation e.g. Max Planck's *quantisation*; Albert Einstein's *relativity*; Max Born's *probability-interpretation* (of the *quantum* world); Werner von Heisenberg's *uncertainty principle*; Kuhn's notion of *paradigm*; and Crick, Watson and other's ideas of *genes* and *heredity*. This second level of the big idea leads to a third: how words and ideas from science become modern metaphors e.g. "political DNA" and the "ecology of power". (Metaphor-making from the ideas of science is not unique to science. Other human and cultural activities also insert terms into common speech that enhance our ability to render private thoughts and descriptions public. Thus we "*segue*" (cf. music and dance) from one idea into another; we try to discern "*texture*" (cf. art and painting) in an argument; and a particularly self-indulgent individual is described as "*anal*" in a quaint genuflection to Freudian psychoanalysis. Metaphors and the images they import become patterns of thought. Insofar as these come to us from science, it is important for science educators to ensure that they are properly understood.

Fractal geometry, a recent mathematical idea developed by Benoit Mandelbrot and others, has introduced a powerful big idea: *chaos*. Chaos is no longer the disorder brought to the world (of the ancient Greeks) abandoned by the pantheon of gods. Now it is the more subtle idea that describes how apparently ordered systems can be reduced to "chaotic" behaviour by minute disturbances in initial conditions. A now-famous saying about weather systems – which are chaotic in the new sense of the word – is that when a butterfly flaps its wings in Calcutta it causes a tornado in Cape Town. Chaos theory is now used to analyse systems ranging from aerodynamics to financial markets to sporting strategy. The idea is also used (both correctly and incorrectly) in everyday conversation. The modern science teacher must remain current and appreciate new ideas as much as knowing about the historical development of science and where ideas came from.

From time to time fresh lists of big ideas are proposed. According to Clive Cookson of the Financial Times (24/11/2007) the "top 10 most influential" big ideas then were:

1. Evolution
2. Atoms and Nuclear Reactions
3. Genes and DNA
4. Radiation
5. Big Bang
6. Molecules and Chemical Reactions
7. Relativity
8. Digital Data
9. Quantum Mechanics
10. Statistical Significance

Another list is that of the Lawrence Hall of Science's GEMS ("great explorations in mathematics and science") Programme at the University of California at Berkeley. It was compiled in the 1980s and apart from Cookson's "digital data" the two lists are very close. Cookson's list illustrates how quickly big ideas can appear.

1. Energy
2. Models, laws, theories & simulations
3. Matter, materials and structure
4. Scale (and measurement)
5. Patterns of change
6. Stability
7. Interactions
8. Diversity and unity
9. Evolution
10. Cause and effect; and evidence

The proceedings of a 1994 conference held at the University of the Witwatersrand to discuss a new SA science curriculum drew from but added further big ideas to the GEMS list. Some of the items show how local and otherwise ephemeral ideas can assume great importance at particular times.

1. Conservation and change
2. Life processes
3. Systems
4. Values in science
5. Environment
6. Science as process
7. Equilibrium; action and reaction
8. Interrelation of Technology and Culture
9. Interdependence
10. Probability and risk

Big ideas like these can become organising themes for a science (education) curriculum. However big ideas are not "one size fits all" categories but rather "fit for purpose" and so they will differ from phase to phase as the curricular focus changes (see Addendum 6: General Features). Big ideas extend beyond scientific concepts alone and science teachers must also appreciate how their "curricular" big ideas become metaphors that influence how we think and talk. The importance of science in modern society is unequivocal and ITE courses for science teachers must prepare them to encourage intelligent engagement with "science" issues. The FET group conducted an exercise to tease out its own "big ideas" from the FET curriculum. It found that the following ideas were required and mentioned either directly or implicit in the curriculum and thus deserved ITE trainers' attentions: *the Anthropocene; change (chemical- and physical change); charge; conservation (and non-conservation); continuum versus discrete; electrochemistry (transformations of energy); energy and mass-energy (forms of energy); (chemical) energetics; entropy; evolution; fields; how we know; modelling; (particle) nature of matter (kinetic theory); periodic table; rate; reaction (types of reaction e.g. redox; rate of reaction; reaction kinetics); scale and measurement; space, time and space- time; stoichiometry (and relation to discrete particles); structure; systems; taxonomy; technology; universe and cosmology; and waves … .* Any list of big ideas is necessarily open-ended.

The big idea can be a manifestly scientific notion; or it can be one that is important in science. For ITE, big ideas are not simply about the idea as an organiser *per se* but also about how they can escape the boundaries of science into philosophy, common thought and everyday language. By considering both the big ideas of science and in science we gain the means to teach not only about the impact of science on (modern) society but how the demand for "scientific literacy" is made of every participating citizen.

Addendum 3: ROLE OF MATHEMATICS

The role of mathematics, historically and in current advances in science, coheres around certain questions. Their investigation can illuminate the role of mathematics in science and provides a lever for studying the history of science. The consequence of studying the history of science is to better understand its nature.

The kinds of questions we ask are:

- What is "pure" mathematics?
- What is the difference between "pure" mathematics and "pure" science?
- Why is mathematics important to scientific advancement? (See Addendum 4.)
- When did mathematics enter the field of science? (See Addendum 4.)
- How has mathematics supported scientific advancement?
- What kinds of mathematics can be, or are used in science?
- And where, when and how were different kinds of mathematics used?

- What is the relation between mathematics and scientific discovery?
- Is mathematics the language of science?

Content is very important in the FET phase and therefore it is important that teacher trainers are able to teach necessary content to the conceptual levels required. This requirement applies to the science but also to mathematics that is used in that science. Beneath this requirement is the idea that in order to teach with confidence and to ignite real excitement in teachers-in-training, the trainers' own knowledge must be in excess of what is required by the FET curriculum. (The same applies, but to an attenuated degree, to teachers and school learners.) The knowledge referred to her includes not so much deep mathematical expertise but rather sufficient expertise coupled with real appreciation for the role that mathematics plays in science.

Addendum 4: THE HISTORY OF SCIENCE AND MATHEMATICAL PHYSICS

Applications of mathematics to that form of inquiry known as "science" (and, in particular, "physics") must be appreciated; and so too the relationship between mathematics and science in the history of scientific advancement. The Journal of Mathematical Physics defines this field as "the application of mathematics to problems in physics and the development of mathematical methods suitable for such applications and for the formulation of physical theories".

It is important to appreciate the central questions and themes at key moments in the history of science; and the influence that time, place and purpose have had on scientific development. For instance Archimedes, one of the great mathematician-scientists of antiquity, devoted much of his working life to the invention of military machines for the King of Syracuse. He based his scientific and technological occupation mostly on the mathematical principles of mechanics. He also knew enough mathematics of curves to design parabolic mirrors intended to burn attackers' boats. This invention would have influenced studies of heat, and thus energy. Archimedes could also use the mathematical method of infinitesimals to solve problems. In this he pre-empted Newton and others by two thousand years! The important point here is that the idea of using mathematics in science was established early and certain mathematical theory was developed well before its use in later advances like Newton's theories of motion and gravitation.

For centuries mathematics has been used at critical stages in the development of virtually all branches of physics. In classical mechanics Newton is generally held to be the greatest mathematical physicist of all time. But Newton "stood on the shoulders of" Greek mathematicians (notably Euclid) as well as the mathematician-scientist-natural philosophers of early Islam e.g. Al-Khwarizmi (or Algorismi), Avicenna, Geber and Alhazen. From these beginnings the Christian world gave us Tartaglia, Stevin, Galileo, Kepler and Huygens, a contemporary of Newton. In the early 18th century Newton's approach was systematised and synthesised with the mathematics of Leibniz and Johann Bernoulli; and in the later 18th and 19th centuries the mathematical work of Daniel Bernoulli, Euler, d'Alambert, Laplace, Lagrange, Fourier and Hamilton contributed to the grand synthesis of analytical mechanics (especially Lagrange's *Mecanique Analytique* published in 1788) and encouraged and enabled ever greater rigour in studies of the natural world.

In the understanding of magnetism and electricity, seeing them as the result of "emanations" held up progress until mathematical physicists reduced both to "forces at a distance" in the style of Newton's gravitation. Cavendish, Coulomb, Volta and others introduced concepts of charge, capacity and potential, allowing the likes of Gauss and Poisson to establish the mathematical bases for electro- and magnetostatics. The empirical discoveries of Ampere and Faraday then enabled James Clerk Maxwell, one of only two or three people who can arguably challenge Newton for the title of "the greatest" mathematical physicist, to advance the ultimate mathematical description of the electromagnetic force.

As appreciation grew of the minuteness of natural particles and their presence in almost infinite number (a culmination of thought originating in ancient Greek ponderings on the nature of matter and the transformative influence of fire and heat) William Thompson (Lord Kelvin), Maxwell, Boltzmann, Gibbs and Poincare gave to science the notion of probabilistic interpretations of nature. This evolved into thermodynamics, the general treatment of heat and energy. Electromagnetism and thermodynamics, the two primary salients of modern (mathematical) physics, with Maxwell's work central to both, prepared the ground for the most important scientific upheavals since Copernicus and on scales many orders of magnitude apart: relativity and quantum theory. As the 19th century drew to a close mathematical physics, with Planck and Einstein its lead protagonists, assumed a permanent position in science. Einstein's general theory of relativity took cosmology "universal" at almost the same time that Planck's quantisation of energy thrust upon the world the intellectual firestorm of quantum theory. And all of this was couched in mathematical formulation.

Perhaps it was inevitable that the toils of the high priests of quantum theory (Planck, Bohr, Schrodinger, Born, Dirac, Feynman, Gell-Man and others) and relativistic cosmology (Einstein, Hoyle, Penrose, Hawking and others) should converge. There had been other convergences before e.g. Maxwell's unification of magnetism and electricity. Theoretical physicists like Einstein, Weyl and Hawking all contributed to the continuing quest for a unified theory that sought to meld the theories of the unbelievably small and the unimaginably large. It seems inconceivable that any curricula purporting to prepare intending high school teachers should omit at least the telling of these sagas. For too long science teachers have not been required to appreciate the history of their subject: an exciting story full of the romance and intensely human dramas one expects from great (intellectual) quests. Not only have the ideas and discoveries of science – abetted, as they are, by mathematics – sharpened our understanding of the natural world. Many of the big ideas of science and discoveries have also enriched human discourse by percolating through our everyday speech and thinking.

Addendum 5: BEING EDUCATED

In general terms, education must empower; that is, it must enable people to accomplish and achieve what is important to them but which they are unable to accomplish or achieve without that education.

Michael Oakeshott's explanation of (liberal) education is that education is essentially about transformation through the enhancement of the skills and forms of knowledge – including all forms of communication; knowledge of the world around us and the animate and inanimate objects that inhabit it; and an ability to perceive subtle interactions amongst the inhabitants of our worlds – that make us human.

Education as an institutionalised enterprise crystallises around the notions of interaction and transformation. It therefore stands to reason that the content of education consists of ...

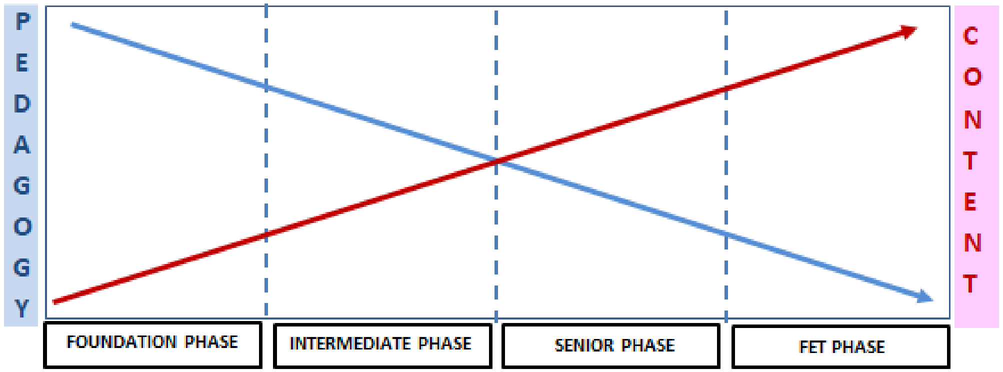
- the cognitive and intellectual interaction with humankind's accumulation of knowledge i.e. our language(s), mathematics and history etc.;
- an appreciation of biological and energetic interactions between and amongst animate objects and their environments;
- apprehending the rules of interaction among rational beings having objective and subjective knowledge and habits;
- understanding physical interactions in the natural world and ways of investigating them;
- the interaction of humans with their natural and built environments in an effort to use or control them and technologies resulting from them; and
- the development of specific, human skills, particularly in the world of work, that enhance our ability to interact more effectively with our worlds and others who live in them.

It follows that education will not be transformative unless there is an *a priori* commitment by learners to transforming their existing condition through active engagement. In practical terms this means that to become educated or more educated – and hence more fully human – a learner must consciously want to learn. Ideally, motivation for learning is intrinsic where the learner actively seeks opportunities to find or develop solutions to perceived needs and wants. However extrinsic motivation is also possible. Learners can be persuaded to recognise gaps in their knowledge and skill sets, thus creating a commitment in a willing learner to seeking ways of bridging those gaps.

Addendum 6: GENERAL FEATURES OF PRE-SERVICE PROGRAMMES FOR SCIENCE TEACHERS

Features applicable to ITE for the specific phases as well as the skills of candidate teachers in those phases were discussed. Some were joint discussions of the mathematics and science groups, hence the inclusion here of features like mathematical fluency and competence. A common theme that arose for both mathematics and science groups was the role of language. Language issues were also felt to be nuanced according to phase. Yet another feature that arose was the minimum level of content competence required by teachers in a particular phase. In fact the FET group makes a firm proposal in respect of the content knowledge requirements of FET Phase science teachers viz. NQF Level 6 knowledge of physics, chemistry and the appropriate life sciences subjects.

As a general rule it seems that pedagogy may increase in importance towards the foundation phase end of the school continuum whereas the importance of content competence advances in the opposite direction:



This is not to say that pedagogy is unimportant at the FET level; nor does it say that content *per se* is unimportant in the Foundation Phase. But it does say that in the FET Phase, subject-specific content as a category is critical whereas pedagogy, for older learners who have developed their own modes of learning and have learned to cope with teaching styles not entirely in synch with their preferred modes, is less so. This means that content instruction in the pre-service course for an intending Physical Sciences teacher is critical whereas as pedagogy is not. Conversely, for the pre-service training of Foundation Phase teachers whose content knowledge of science or mathematics will either be adequate or easily made so, the matter of pedagogy and the how of teaching very young learners is critical. This pattern applies to different degrees for the general features of ITE across the four phases of school education. In most cases, however, the features are progressive with each successive phase building on the work of the previous phase.

	Foundation Phase	**Intermediate**	**Senior**	**FET**
Pedagogy & curriculum (1)	less formal content	introduction of basic concepts largely through experiences and increasing through the phase	content formalised around four strands of scientific enquiry and science learning	more content; formalised around recognised divisions of physical sciences

Pedagogy & curriculum (2)	activity-based around important skills e.g. classification	activities drawn from four strands of scientific enquiry and science learning	activities increasingly content-based practical work and projects	activity focused on practical investigations and hypothesis testing
Pedagogy & curriculum (3)	strong emphasis on process and process skills	strong emphasis on process and process skills	… process skills emphasised within framework of formal scientific investigation	activity emphasises application of process skills to formal investigations and real experimentation
Pedagogy & curriculum (4)	counting, ordering, simple classification and proto-pattern seeking	use developing spatial and numerical skills to classify in order to find patterns	emphasis on use of mathematical skills increases through phase, including simple formulations	abstract ideas (e.g. fields) articulated in mathematical terms for use in problem solving
Pedagogy of pre-service curriculum	major focus of programme is on pedagogy and learning styles of fph children but pedagogy related to scientific method and thinking wherever possible	focus on pedagogy and learning styles of iph children but pedagogy related to scientific method and thinking and appropriate issues wherever possible	pedagogy is related to scientific method and process skills with appropriate reference to the historical development of the topic at hand	pedagogy is strongly related to scientific method and process skills with strong, intentional reference to historical development of science topics (and mathematics, where appropriate)
Habits of mind	critically important and potentially a set of learning categories around which the foundation phase curriculum could be organised; the bases for school learning	much attention still paid to the establishment of appropriate habits of mind in the formal pedagogy; scientific habits of mind covertly and overtly celebrated in teacher education curriculum e.g. respect for evidence and classifying data	habits of mind now being consolidated into regular, academic and life-learning behaviours; habits appropriate to science overtly taught and exercised e.g. systematic observation and pattern seeking and recognition; developing	habits of mind now well established in most learners; scientific habits of mind now overtly celebrated in science teacher pedagogy; curriculum assumes learners to be operating along these lines e.g.

			conscious commitment to "thinking like a scientist"	actively seeking evidence; analysing; systematic recording and categorising; finding associations across disciplines; hypothesising, predicting and testing … thinking like a scientist
Linguistic fluency and competence	excellent; appropriate to grade level	excellent; appropriate to grade level	excellent; appropriate to and extending beyond grade level	excellent; appropriate to and extending beyond school level
Mathematical fluency	grade level + 1 year	grade level + 2-3 years	matric level	first year university level or beyond
Mathematical competence	can engage at least at grade 9 level	can engage at least at grade 10 level	can engage at least at matric level, preferably beyond	can engage at least at university first year level, preferably beyond
Science content competence	excellent science general knowledge; no fear of appropriate science topics or of process skills	excellent science general knowledge; specific knowledge to grade 9 level; willingness to engage in investigations	excellent science general knowledge; specific knowledge to first year university level in at least one science subject	excellent science content, general knowledge and practical skills to at least university second year level in physics & chemistry
Affective aspects of science teaching style	shows genuine enthusiasm for science and science enquiry; able to make activities "fun"; teaching style relaxed and informal	exudes confidence and enthusiasm for science and science enquiry; able to encourage others to see science activities as "fun"	stimulates confidence and enthusiasm for science and science enquiry by way of well-planned, relaxed and orderly yet un-regimented lessons	exudes confidence and enthusiasm for science and science enquiry; able to encourage others to see science activities as "fun"
Science and society &	good "feel" for and sound basic knowledge	good "feel" for and sound basic knowledge of STS issues etc.*	conversational knowledge of the history of science and role of	excellent knowledge and understanding of the history of

the history and language of science & big ideas	of STS issues etc.* for personal growth but not teaching purposes *including role and history of mathematics, big ideas and languages of science	for personal growth but not teaching purposes *including role of mathematics, big ideas and languages of science	mathematics; good understanding of the history of science development; basic knowledge of STS issues etc. for teaching purposes	science and role of mathematics in science development; good knowledge of STS issues etc. for teaching and extracurricular enrichment purposes