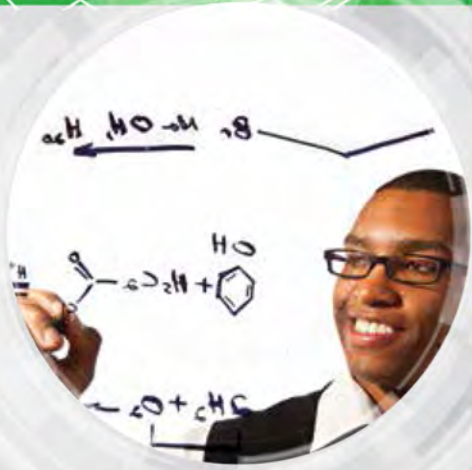
# What's in the CAPS package?

# Natural Sciences



UMALUSI
Council for Quality Assurance in
General and Further Education and Training

# What's in the CAPS package?

A comparative study of the

National Curriculum Statement (NCS) and the

Curriculum and Assessment Policy Statement (CAPS)

## Further Education and Training (FET) Phase

## Natural Sciences


| Life Sciences | Physical Sciences |
|---|---|
| Dr ER Dempster | Dr S Grussendorff |
| Mrs E Cilliers | Ms A Isaacs |
| Mrs K Johnson | Mrs M Stephen |
| Mrs P Majozi | Dr A van der Hoven |
| Mrs P Pillay | Miss N Zuma |
| Ms S Wiese | |

With
Dr S Grussendorff
Dr C Booyse



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UMALUSI
Council for Quality Assurance in
General and Further Education and Training

37 General Van Ryneveld Street,
Persequor Technopark, Pretoria

Telephone: 27 12 3491510 • Fax: 27 12 3491511

Email: Info@umalusi.org.za • Web: www.umalusi.org.za

# ACKNOWLEDGEMENTS

This Natural Sciences cluster report includes the findings emanating from the comparative analysis of the Further Education and Training (FET) National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statement (CAPS) for Natural Sciences and a summary of findings from Part 2 of the research. Part 2 of the research has had as its intent the determination of entry level requirements and expected learner attainment on exit level. A summary of the exit level outcomes for these subjects also appears in the Overview report.

The research project was co-managed by Dr Celia Booyse (Manager: Curriculum, Umalusi) who coordinated all project processes and Dr Sharon Grussendorff who in particular provided comments on the subject reports and prepared all the excel spread sheets for the transfer of data. Besides being a renowned researcher, Physics lecturer and consultant for many educational initiatives Dr Sharon Grussendorff has, since 2006, been involved in the Umalusi research initiatives. The QCC and SIR units have drawn extensively on her report writing skills and project management abilities over the years. In 2012, Dr Grussendorff has been approached to co-manage the research projects and in particular to lead the FET Phase Physical Sciences team. Her experience in teacher-support and the training she has undertaken for JET in curriculum interpretation and implementation are considered invaluable for these research initiatives.

Dr Booyse has been steadily supported by her colleagues in the Qualifications, Curriculum and Certification (QCC) unit: Ms Elizabeth Burroughs: Senior Manager: QCC and Mr Duma Sithebe, Assistant Manager: Curriculum. The support and encouragement from Ms Burroughs is well appreciated. Her first line of editing and the writing of the final concluding remarks are noteworthy.

Mr Sithebe ably assisted in constituting the evaluation teams, dealing with communication and undertaking the greater part of the document search for the comparative research, each of these a considerable undertaking.

Mr Mohau Kekana, Administrative Assistant (QCC) is thanked for the quality assistance in logistics and project administration. His efficient and dedicated contribution to the research project is commendable.

The teams who have undertaken these evaluations have far exceeded the call of duty, and for that we at Umalusi thank them. A particular word of appreciation goes to the team leaders for the coordination of team efforts and taking up the final responsibility of finalising the subject report.

The unstinting hard work and willingness from both team leader and team members must be duly acknowledged. The positive attitude within the teams and the in-depth discussions and collaboration are commendable. It has been satisfying to see that we have all learned from one another's expertise, and that all who have participated in the process go out with an enriched understanding of the importance of curriculum and its appropriate implementation.

It is worth referring to Annexure A in the Overview Report to fully appreciate the wealth of experience and commitment this project has been privileged to draw upon. The teams who contributed to this Natural Sciences cluster report are:

## LIFE SCIENCES

Dr Edith R. Dempster - Team leader of the Life Sciences team, education consultant and Senior Research Associate in Science education

Mrs Elizabeth Cilliers - HOD for Life Sciences, Physical Sciences and Natural Sciences at C. R. Swart High School, Gauteng

Mrs Kathryn Johnson - Teacher Trainer: CAPS Life Sciences

Mrs Phumzile Majozi - Senior Education Specialist: KZN

Mrs Prabha Pillay - Senior Education Specialist: KZN

Ms Susan Wiese - Deputy Chief Education Specialist for Life Sciences and Agricultural subjects (FET): Gauteng Department of Education

## PHYSICAL SCIENCES

Dr Sharon Grussendorff - Co-manager of Umalusi projects, research consultant and involved in teacher development

Dr Andre van der Hoven - Chemistry consultant; former Senior Lecturer at UKZN

Miss Nompumelelo Zuma - Senior Education Specialist; External moderator (Umalusi)

Mrs Mmapaseka Stephen - Subject Advisor: Physical Sciences

Ms Akeda Isaacs - NSLA projects; Curriculum Advisor

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Without the sustained work of these Umalusi teams and the detailed, extensive reports written by the people duly acknowledged above, the Overview report and this Natural Sciences report could not have been written. Sincere appreciation for every contribution made to the research and to make the reporting on findings possible.

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AS | Assessment Standards |
| CAPS | Curriculum and Assessment Policy Statement |
| DBE | Department of Basic Education and Training |
| Doc | Document |
| FAL | First Additional Language |
| FET | Further Education and Training |
| GET | General Education and Training |
| GIS | Geographic Information System |
| Gr | Grade |
| HESA | Higher Education South Africa |
| HL | Home Language |
| ICT | Information and Communications Technology |
| IT | Information Technology |
| LO | Learning Outcome |
| n/a | Not available |
| n.d. | No date |
| NCS | National Curriculum Statement |
| NQF | National Qualifications Framework |
| NSC | National Senior Certificate |
| OBE | Outcomes-Based Education |
| p | page |
| pp | pages |
| SA | Specific Aim |
| SAG | Subject Assessment Guide |
| SBA | School-based Assessment |
| USSR | Union of Soviet Socialist Republics |

# 1. OVERVIEW: A COMPARATIVE ANALYSIS OF THE NCS AND CAPS FOR THE FET PHASE

## 1.1 BACKGROUND

Umalusi undertook a project in 2013, the core intention of which was to establish the quality of the Curriculum and Assessment Policy Statement (CAPS) as amended version to the National Curriculum Statement (NCS) of 2008. The work done in 2013 is not only an extension of research to further the understanding of the National Senior Certificate (NSC) qualification, but is similar to the comparative research done in 2008. The research such as this not only develops an understanding of the strengths and weaknesses of the subject curricula, but also assists in building bigger picture of the nature of the qualification itself – what its strengths might be and what challenges might arise for the institutions where it is offered and for the staff implementing it. In short, the research was undertaken with the purpose of ensuring a better understanding of the NSC for all involved.

The current phase of the research is presented in the following reports:

- An overview report of the research process and key findings for subjects and subject clusters
- A series of subject/subject cluster- specific reports for Mathematics, Mathematical Literacy, Languages (English), Social Sciences, Natural Sciences and Business, Commerce and Management

Initially the reports will be submitted to the Department of Basic Education and Training (DBE). The findings and recommendations have been formulated as guidelines for improvement, in terms of both the national policy and of implementation and assessment. The findings also point to areas that need strengthening in teacher education and professional development. Thereafter, Umalusi, in collaboration with Higher Education Institutions and Higher Education South Africa (HESA), could use this research work towards improving the quality of teacher preparation, not only to equip teachers as field experts, but also as subject methodologists who are able to reflect on their own teaching practice.

## 1.2 THE RESEARCH QUESTION, RESEARCH METHODOLOGY AND INSTRUMENT

**Research question:** The research question for the comparative NCS/CAPS research/evaluation is worded as follows:

*'What does the comparison between the Curriculum and Assessment Policy Statement (CAPS) for FET Phase (Grades 10 to 12) and the National Curriculum Statement (NCS) reveal about:*

a. *the extent to which the NCS curricula were repackaged or rewritten in the formulation of the CAPS;*
b. *the relative depth and breadth of the content covered in the respective curricula,*

c. *the overall design, structure and coherence of the curricula,*
d. *the level of specification of various aspects of the curricula, and*
e. *the guidance provided by the curricula for the teaching and assessment of the subject?'*

**Research/evaluation process:** The process involved identification of the evaluation teams across all the subjects under evaluation, followed by the refining of an existing instrument to evaluate and compare the NCS and the CAPS. Thereafter two workshops were held with the evaluation teams, in September and November of 2013, in order to brief them about the evaluation and for the teams to work together on the curriculum analysis. Finally, the evaluation teams completed their analysis via e-communication, and the team leaders took responsibility for the completion and submission of the teams' reports.

**Instrument:** An instrument was customised for this investigation, which required the evaluators to grapple deeply with issues around broad curriculum framing, and concepts such as content breadth and depth, sequencing, progression, coherence and how to determine the weighting and curriculum focus in the documents. All those who participated in the process learned a great deal, and they in turn offered insights from their own expertise which added value to the report.

The evaluation teams were asked to give their opinion on each subject regarding:

- Broad curriculum design – the central design principle;
- The aims/ objectives of the subject;
- The ideal learner envisaged;
- The weighting of each topic in terms of the percentage of time allocated to each;
- The emphasis placed on content and skills;
- The depth of the subject in terms of the extent to which learners could move from a superficial grasp of a topic to a more refined and powerful grasp;
- The degree to which the curriculum of each subject is paced, in terms of the volume to be covered in a specific timeframe;
- The specification of sequencing of topics;
- The progression of topics from Grades 10 to 12 in terms of increase in level of complexity and difficulty;
- The coherence of the curriculum for each subject, in terms of connections and coordination between topics through the levels;
- The degree to which teachers are given explicit guidance regarding pedagogy;
- The degree to which teachers are provided with guidance regarding assessment;
- Format and user-friendliness of the curriculum documentation.

Evaluators were asked to comment on the overall guidance and use of the curriculum and the central values underpinning each curriculum.

In addition, the teams had to substantiate their opinions about the extent to which the CAPS for the subjects mentioned above have been 'repackaged' or been rewritten in this repackaging process. The teams were asked to identify the extent to which the repackaging has extended – or contracted – the content and skills which learners are expected to acquire and teachers to teach. Another point for attention was whether the CAPS provides better guidance to teachers than the NCS.

Lastly the evaluation teams were required to make recommendations, based on their findings regarding all the points above. They were requested to provide recommendations for the strengthening of the CAPS for each subject, where these may still require improvement. Such recommendations will form the basis for subsequent work to be undertaken by the DBE and monitored by Umalusi.

## 1.3 TRENDS ACROSS THE CURRICULA

Although the Umalusi subject evaluation teams worked towards a common goal of assessing the comparability of the NCS with the CAPS, the individual subject reports offer unique insights, with particular details that are of interest to those involved with teaching the subjects in question. There are, however, overarching trends that can be gleaned from the subject reports. These trends are briefly described below. A more detailed section on the trends across the curricula appears in the Overview report.

### 1.3.1 The nature of the curriculum documentation

The NCS documents had a great deal of uniformity in style and length across the different subjects, however, the CAPS is somewhat varied between subjects. For some subjects, such as Life Sciences and Physical Sciences, a full teaching programme is provided, with the content and prescribed activities clearly described with definite timeframes. By contrast, the documentation for some subjects, such as History, only provide a list of content to be covered per term, with no time indications for separate topics. The extent of the assessment guidance also varies substantially between subjects, with the Mathematics CAPS containing the shortest guidance on assessment (five pages), while the guidance provided for Mathematical Literacy covers 32 pages. The CAPS documents for English HL and English FAL both contain glossaries, which none of the other subjects have.

The table below (Table 1) illustrates the variation in the length of the subject-related curriculum documents for the CAPS compared with the NCS.

| Table 1: Variation in the length of curriculum documents | | |
|---|---|---|
| | **NCS** | **CAPS** |
| Lowest number of pages | 139 (Accounting) | 48 (Economics) |
| Highest number of pages | 204 (English FAL) | 164 (Physical Sciences) |
| Average number of pages | 175 | 82 |

This table shows that there is much greater variation in the length of the CAPS documents across the different subjects, ranging from 48 pages (Economics) to 164 pages (Physical Sciences) in length, compared with the collection of NCS subject-related documents, which range from 139 pages (Accounting) to 204 ages (English First Additional Language (FAL)). Each subject varies in terms of the approach taken to the way in which guidance is given to the teacher. This may contribute positively towards the CAPS providing clear and appropriate guidelines within each subject, but it does suggest a lower degree of coherence across subjects in terms of the approach taken within the curriculum documents.

In all subjects, with the exception of Physical Sciences, the **length** of subject-related documents that teachers need to consult has been **reduced** from the NCS to the CAPS. (This does not include the Examination Guidelines document for the CAPS, which may cause the number of pages in the CAPS documentation to exceed that of the NCS in some cases). The reason for the greater length of the Physical Sciences CAPS is that this document has a very detailed level of specification, which will be discussed further under the Specification heading.

In all subjects, the evaluation teams deemed the CAPS documents to be more **user-friendly** than the NCS equivalents, mainly due to the number of subject-specific policy documents that had to be consulted in NCS (a minimum of four). The result of this level of documentation meant that lesson preparation became complicated and unwieldy for teachers using the NCS.

The accessibility of the **language** was generally deemed acceptable for both curricula. Some of the evaluation teams commented on the complexity of the educational 'jargon' used in the NCS when describing OBE. This has been reduced in the CAPS, where much simpler language is used to describe the teaching and learning process.

For all subjects except Accounting, there has been an improvement in **alignment** between the documents within each curriculum. Many of the evaluation teams reported that there are contradictions between the various subject-related documents for the NCS. The only evaluation team that did not report alignment problems in the NCS documentation was the Accounting team. As the CAPS has only one subject-related document at the time of the evaluation, meant that the misalignments between documents are no longer an issue.

However, some of the evaluation teams reported alignment issues between the various undated ***versions*** of the CAPS documents which were released during the implementation process. (This caused great confusion among teachers and other education practitioners, who were unsure of whether they had the latest version of the CAPS). In addition, as an Examination Guidelines document has been introduced, it is possible that problems with alignment may occur with the CAPS.

Evaluation teams for all subjects agreed that the **design principle** of the curricula has shifted from outcomes-based in the NCS to content-driven or syllabus-based in the CAPS. Where an outcomes-based curriculum is, by nature, learner-centred and activity-based, a content-driven curriculum involves a more teacher-centred, instructive approach. However, both of the languages evaluation teams (English FAL and English HL) commented that, although the CAPS is teacher-driven, there are some skills-based principles involved, such as text-based approaches, with content based on topics and themes.

Overall, the evaluation teams concluded that the CAPS documents are an improvement over the NCS in terms of the design and structure of the curricula. The recommendation made in the Department of Education (DoE) report (2009, p 63) for *'consistency, plain language and ease of understanding and use'* has been heeded in the compilation of the CAPS.

### 1.3.2 Curriculum objectives

The evaluation teams were asked to compare the objectives that are stated for their subjects in the NCS with those in the CAPS. The general finding across the subjects was that the objectives are very similar for both curricula. (These findings are presented in detail in the individual subject reports). Some of the NCS objectives which are related to socio-political and ethical awareness, and sensitivity to cultural beliefs, prejudices and practices in society, have been excluded from the CAPS. In addition, where the NCS addresses the need for the development of skills related to self-employment and entrepreneurial ventures, these skills are not included in the CAPS objectives.

The English FAL evaluation team noted that the CAPS omits objectives that include human experience, aesthetics of language, and social construction of knowledge. They commented that *'the CAPS has removed the explicit recognition of unequal status of languages and varieties - a key specific objective articulated in the NCS'*.

The Mathematics evaluation team noted that there is *'a de-emphasis in the CAPS of the more explicit transformatory agenda that is articulated in the NCS'*. This is perhaps appropriate, given the historical timing of the two versions of the curriculum, with the NCS being introduced during a time when *'the notion of a national curriculum was a new concept that coincided with the birth of a new democracy'* (DoE, 2009, p 11) and the CAPS, after more than a decade of democracy.

### 1.3.3 Breadth and depth of content

One of the areas that is repeatedly highlighted in the DoE report (2009) is that of finding a balance between breadth and depth in the content of the curricula. It has been shown that less breadth of content covered in more depth ensures a greater chance of future success in the discipline (Schwartz *et al.*, 2008). With this in mind, the evaluation teams compared both the breadth and the depth of the NCS and the CAPS in order to determine any shifts that may have taken place in these areas.

The Economics and Mathematics evaluation teams reported an **increase in the breadth** of content across the FET Phase in the move from the NCS to the CAPS. The English HL, Accounting, Business Studies, and History evaluation teams concluded that the **breadth across the FET Phase is similar** for the NCS and the CAPS. The Physical Sciences, Life Sciences, Geography and English FAL evaluation teams reported a **reduction in the breadth of content** across the FET Phase in the CAPS curriculum compared with that in the NCS.

### 1.3.4 Depth

An **increase in depth** from the NCS to the CAPS was noted for Economics and Mathematics. The Accounting, Business Studies, Geography and Physical Sciences evaluation teams reported a **similarity in the depth** required across the FET Phase for the NCS and the CAPS, whereas the English FAL and Life Sciences evaluation teams reported a **reduction in overall depth** from the NCS to the CAPS.

The English HL evaluation team could not comment on depth, since this is left to the discretion of the teacher in terms of the length and complexity of texts that are selected. They made the comment that, although some guidance is given in the CAPS around the selection of appropriate texts, this is insufficient to ensure a common understanding of the level of depth that is required.

The History evaluation team could not compare the depth of the curricula because of the structure of the content outline provided in the NCS, which does not give sufficient detail to provide any form of guidance on the level of depth required. The evaluation team commented on the depth of the CAPS itself, that *'the CAPS manages the tensions between breadth and depth as well as is possible, although there is probably a greater emphasis on breadth than depth'*.

The Mathematical Literacy evaluation team could not compare the depth of the curricula because the NCS defines depth in terms of the mathematical processes involved, whereas the CAPS defines depth in terms of the level of problem-solving required within the selected real-life situations or contexts. Hence, although in one sense the NCS has greater depth than the CAPS, since it contains topics that require application of more complex mathematical skills, the evaluation team noted that the CAPS goes into greater depth than the NCS in almost every topic, since learners are expected to know more about the topic and to understand the complexity of the authentic real life situation.

### 1.3.5 Specification of content

The curriculum specification, or degree to which knowledge is broken down for stipulation, was compared for the NCS and the CAPS. On the whole, it was found that the level of specification of content is higher in the CAPS than in the NCS. More detail is provided in the CAPS on the exact scope and depth of the content that is to be taught and assessed, than in the NCS. However, three of the evaluation teams, namely those for Economics, English HL and English FAL, did not report an increase in specification of content in the CAPS.

In terms of satisfying the recommendation made in the DoE Report (2009, p 62) that curricula should provide *'clear, succinct and unambiguous'* statements of learning, the majority of the CAPS subject documents satisfy these criteria. Nevertheless, particular attention must be paid to the level of clarity provided in the two English language curricula, to ensure that these provide the necessary guidance to teachers. In addition, many of the subject evaluation teams reported that the CAPS documents require a thorough edit, as there are numerous errors that appear throughout the documents, which may lead to confusion and erroneous interpretation of the curricula.

### 1.3.6 Pacing

All of the evaluation teams, with the exception of Mathematical Literacy, agreed that the **level of stipulation of the pacing** is greater in the CAPS than in the NCS, since more explicit guidelines on time frames are provided in the CAPS. The Mathematical Literacy evaluation team found that the work schedules in the CAPS do not provide sufficient detail about the actual content to be taught or the resources needed for the teaching to allow for a clear sense of pacing. They also found discrepancies between the suggested work schedules, which specify broad content for each week (Mathematical Literacy CAPS, pp 16-20), and the summary of the number of weeks to be spent on each topic (Mathematical Literacy CAPS, p 15).

The evaluation teams were asked to comment on the **actual level of the pacing** for each of the curricula as it would be experienced by learners in the FET Phase. The pacing was difficult to judge in the NCS due to the low level of specification, and the flexibility granted to teachers to determine the pace in response to the varying needs of learners. In spite of this lack of specification, however, some of the evaluation teams were able to make broad judgments on the levels of pacing, based on the breadth of content stipulated within the overall time frame for each grade. On this basis the **Physical Sciences,**

**Accounting, Economics, English FAL** and **Geography** evaluation teams indicated that the pacing of the NCS was likely to be experienced as fast. The remaining evaluation teams were either unable to comment on the pacing, or considered the pace to be moderate.

For the CAPS, evaluation teams for all subjects except for **Geography, Mathematical Literacy** and **Life Sciences** commented that pacing is likely to be experienced as fast, since the time allocation for teaching the content does not allow for a sufficient depth of engagement with the content as specified. The Geography evaluation team concluded that the pacing is carefully considered and realistic in the CAPS. The Mathematical Literacy evaluation team deemed the pacing to be moderate, based on their overall impression of the material to be covered. The Life Sciences evaluation team considered the pacing to be fast for Grades 10 and 11, and commented that *'the experience of teachers is that they have to rush through the curriculum to complete it in the year'*. They considered the pacing to be moderate for Grade 12, but mentioned that the pacing is uneven, in that *'too much time is allocated for some topics, and too little for others'*.

### 1.3.7 Sequencing and progression

In general, the evaluation teams found the **degree of specification of the sequencing** to be higher in the CAPS than in the NCS. This is to be expected from a curriculum which has been designed to provide a structured learning programme, as does the CAPS, in contrast to the approach taken by the NCS, which is to allow teachers the flexibility to design their own learning programmes.

The evaluation teams were asked to make a judgment on whether **progression within each grade** is evident in the NCS and the CAPS. Interestingly, although there is no expectation in the **NCS** that teachers follow the sequence of topics as they are laid out in the curriculum, many of the evaluation teams found that the order in which the topics are laid out in the curriculum offer an inherent sense of progression. However, a wide range of interpretations of the sequencing of topics by textbooks, provincial departments and other interpreters of the curriculum meant that this inherent progression was not always followed through in practice. For the **CAPS**, no clear trend is evident across the subjects in terms of the sequence of topics allowing for progression within each grade. The reasoning behind the sequencing of content is not always clear, and in some cases does not appear to have been designed with progression in mind. An example of this is in Physical Sciences, where the Grade 10 CAPS interrupts the flow of certain chemistry topics with the insertion of unrelated physics topics, causing a break in the flow and hence conceptual progression for learners. The Accounting, Economics, Business Studies and Mathematical Literacy evaluation teams all reported strong evidence of progression within each grade.

With regard to the **progression across the grades**, the evaluation teams generally found that progression across the grades in the NCS is clearly evident through the way in which the Assessment Standards (ASs) are expressed, with clear increase in the cognitive demand indicated in the way in which these are described for each grade. Progression in terms of the content across the grades was reported as strong by all evaluation teams except for Physical Sciences, Geography, History, English HL and Mathematical Literacy, where evaluation teams reported either a clear lack of progression, with uneven degrees of complexity across the grades, or a lack of guidance regarding the required level of complexity for the specified topics.

For the CAPS, all of the subjects, with the exception of the language evaluation teams, reported a clear progression across the grades. The English FAL evaluation team made the comment that '*the CAPS offers almost no specification as to the expected depth of topics to be covered in each successive grade, and no indication of progression across the phase*'. The English HL evaluation team reported that the CAPS offers guidelines only as to how progression should take place, but does not give sufficient guidance to teachers to ensure that a clear increase in the level of complexity or difficulty is realised in the learning process. The lack of specification of the length and complexity of texts to be used exacerbates this.

### 1.3.8 Assessment guidance

Both the NCS and the CAPS provide generic guidance to teachers on the purpose, forms and methods of assessment. In addition, subject-specific guidelines are given for each subject in the various subject-related documents.

The **types** of assessment outlined in the NCS are baseline, diagnostic, formative and summative assessment. In addition, a distinction is made between formal and informal assessment. In contrast, the CAPS outlines only two types of assessment, namely formal ('*assessment of learning*') and informal ('*assessment for learning*'). It is noteworthy that the CAPS has conflated firstly, formative and informal assessment, and secondly, summative and formal assessment. In addition, no mention is made in the CAPS of assessment as an aid to diagnosing or remediating barriers to learning.

The NCS describes three **methods** of assessment, namely self-assessment, peer assessment and group assessment. The CAPS narrows this down to self- and peer assessment.

The **methods** of recording assessment in the NCS include rating scales, task lists or checklists and rubrics. The method of recording assessments in the CAPS is based on marks.

With regard to the formal assessment tasks for each subject, most of the evaluation teams reported that the **number of formal assessment tasks** prescribed per grade is equivalent for the NCS and the CAPS, with exceptions being English FAL and English HL, where the number of formal assessment tasks has been reduced, and Life Sciences, where the number of tasks has increased in the CAPS.

In all of the subjects there is a strong **emphasis on tests and examinations** in terms of the overall summative assessment mark in the CAPS. The final mark for each grade in the CAPS is made up of 25% classwork and 75% end-of-year examination. The 25% classwork mark is made up of a high proportion of marks from tests and the June examination. Hence, the minimum contribution of tests and examinations towards the Grades 10 and 11 marks is 80%, and towards the final Grade 12 mark is 85%. This leaves a maximum of 20% representation for projects, practical investigations, assignments and other forms of assessment in Grades 10 and 11, and a maximum of 15% representation of these in Grade 12. While this emphasis may be necessary for assessments to be reliable, it is prejudicial for learners who perform better at tasks that are not test- or examination-based.

The Assessment chapter of the NCS Subject Statements includes a full set of competence descriptors for each level of achievement for each grade, ranging from Level 6 (Outstanding) to Level 1 (Inadequate). In practice, these descriptors were never used, as it was unclear how they should be applied. No such descriptors appear in the CAPS document.

Clearly an attempt has been made in the CAPS to simplify the fairly elaborate approach taken in the NCS. Although this has been necessary in order to reduce the complexity and administrative load caused by assessment under the NCS, it does raise the question of whether valuable insights available through the more nuanced NCS approach to assessment, may have been lost in the process.

### 1.3.9 Curriculum integration

All of the evaluation teams, without exception, found the **level of integration between subjects in the FET Phase** to be low for the CAPS, with little or no explicit mention of reference to fields of learning in other subjects. In the NCS the explicit mention of integration between subjects was only marginally greater than in the CAPS in History, English HL and English FAL. In all other subjects the NCS showed a similarly low level of integration with other subjects, in spite of the stated intention of cross-subject integration.

No clear trends were evident from the findings regarding the level of integration **between the subjects and the everyday (general) knowledge of learners** at their stage of development and in their contexts, since the subjects have varying degrees of applicability to everyday life. Some subjects, such as Mathematical Literacy and Accounting, have a natural link with the everyday world, and these evaluation teams hence reported a high level of integration with learners' everyday lives for both the NCS and the CAPS curricula. Other subjects, namely Economics, Physical Sciences, Life Sciences, English FAL and English HL, reported a drop in the level of integration with everyday knowledge from the NCS to the CAPS. The only visible trend in the findings was that none of the subject evaluation teams reported an increase in the level of integration with everyday life in the move to the CAPS.

The evaluation teams found that the CAPS subject documents as having much clearer discipline-boundaries than those of the NCS. This satisfies the recommendation in the DoE report (2009) for *'statements which are clear, succinct, unambiguous, measurable, and based on essential learning as represented by subject disciplines'* (p 49).

### 1.3.10 Curriculum coherence

The evaluation teams found that the NCS shows clear evidence of an intention for **horizontal coherence**, in its description of integration and its definition of subjects: *'Integration is achieved within and across subjects and fields of learning. The integration of knowledge and skills across subjects and terrains of practice is crucial for achieving applied competence ... In an outcomes-based curriculum like the NCS, subject boundaries are blurred. Knowledge integrates theory, skills and values. Subjects are viewed as dynamic, always responding to new and diverse knowledge, including knowledge that traditionally has been excluded from the formal curriculum'* (DoE, 2003, pp 8, 11). However, this horizontal coherence was not achieved in practice in the NCS, as is evidenced by the lack of explicit guidance for teachers on how to achieve this integration across subjects. Instead, most of the subject evaluation teams commented on the strong discipline-based approach to knowledge in the NCS, which suggests a vertically aligned curriculum structure. This shows a lack of coherence between the stated intention and the actual course structure of the NCS.

The low level of integration between subjects in the CAPS, as mentioned previously, indicates that horizontal coherence is not a design feature of the CAPS documents. The CAPS has a strong discipline-based approach to knowledge within the subjects, as reported by all of the evaluation teams except English FAL and Mathematical Literacy. (It is appropriate that these two subjects are not strongly discipline-based, as they are both subjects which aim to develop literary competence in their respective fields, rather than being disciplines in their own right.) It can therefore be inferred that the CAPS shows a clear and coherent **vertical alignment**, which is evidenced by the clearly demarcated subject boundaries, and the strong discipline-based approach within the subjects. This brings clarity for teachers and learners regarding the exact terminology, content and skill requirements within each discipline. This will lead to a more rigorous induction into the discourse of each discipline for teachers and learners than a more horizontally aligned curriculum would allow. A vertically aligned curriculum does not bring about an explicit development of the ability of a learner to transfer concepts and skills between subjects and into the everyday world.

## 1.4 IMPLICATIONS FOR THE SOUTH AFRICAN CONTEXT

The majority of the evaluation teams agreed that the structured outline of content and activities in the CAPS is more likely to facilitate the development of sound knowledge and skills than the more open, non-prescriptive approach of the NCS. The CAPS is therefore, on the whole, a more suitable curriculum for the current South African educational context. However, the English FAL evaluation team noted that: *'The CAPS is based on conflicting assumptions about teacher expertise. The overt assumptions are that teachers cannot, or should not have to, develop their own teaching plans, and thus they are provided with these. This suggests that the CAPS assumes that teachers do not have the expertise (or time) necessary to develop their own teaching programmes. However, there are so many gaps in the teaching plan, and there is so little specification about depth or progression, that it would require a highly skilled and competent teacher to identify such gaps and failures of logic, and take steps to mediate the plans to address these problems'*.

In addition, some of the evaluation teams expressed concern over the lack of availability of the necessary resources for implementing the CAPS:

- The Economics evaluation team raised the concern that the required learner support materials (such as magazines, newspapers, statistical data and the internet) are not available in all South African classrooms.
- Both of the experimental science subjects, namely Physical Sciences and Life Sciences, quoted statistics that fewer than 5% of South African schools have equipped, functional laboratories (Equal Education, 2012). Both evaluation teams raised the concern that the CAPS is unlikely to be able to be fully implemented in the vast majority of South African schools, given the specialised nature of the equipment required for the prescribed classroom activities in the CAPS.

## 1.5 RECOMMENDATIONS

Each of the subject evaluation teams made specific recommendations for the CAPS for their subject. The following general recommendations are made with the intention of strengthening the CAPS:

- The silence on the role of the teacher in the CAPS documents is concerning. The **place of the teacher** in the learning process needs to be clearly acknowledged and articulated in the CAPS documents.
- Since there has been an implicit shift in the **underlying pedagogy** from a learner-centred to a teacher-centred approach, explicit guidance should be given on what this shift means in terms of the choice of teaching strategies.
- The findings of the evaluation teams show that three of the curricula require **urgent attention**:
    - The **Mathematics** CAPS is deemed by the evaluation team to be significantly more demanding than the NCS, since the CAPS content exceeds that of the NCS in both breadth and depth. This is of great concern, since the NCS Mathematics was already experienced as challenging for a significant portion of the learners. The Mathematics document therefore requires revision to ensure that

there is appropriate provisioning of Mathematics for all learners wanting to take it Mathematics in the FET band.

- o The **English FAL** CAPS is problematic, since not all of the topics mentioned in the content overview in the CAPS are represented in the teaching plans that are provided. The evaluation team made the comment that *'there are so many gaps in the teaching plan, and there is so little specification about depth or progression, that it would require a highly skilled and competent teacher to identify such gaps and failures of logic, and take steps to mediate the plans to address these problems'*. This is a consequence of the unrealistic breadth of content that is outlined in the content overview. The selection of content in the overview therefore needs revision. The teaching plans require reworking, to ensure internal consistency in the CAPS, and to prevent superficial or incoherent implementation of the curriculum. Special attention needs to be paid to the 'Language Structures' section, which, in particular, has major gaps and fails to progress logically.
- o The **English HL** evaluation team found that the clarity of guidance provided in the CAPS is undermined by the lack of guidance regarding the texts to be selected, and the relegation of the teaching of language structures and conventions to an appendix in the CAPS document. It is recommended that, in order to provide clearer guidance to teachers, the teaching plans be revised as follows:
  - More explicit guidance should be provided on the nature and complexity of texts to be selected.
  - The teaching of language structures should be integrated as part of the teaching plan.

- The CAPS documents require a **thorough edit**, as many of the subject evaluation teams reported that there are numerous errors that appear throughout the documents, which could lead to confusion and erroneous interpretation of the curricula. Many of the evaluation teams also commented on typographic and spelling errors in various places throughout the document which require a thorough language edit.

## 1.6 CONCLUDING IDEAS

In the move from the NCS to the CAPS there has been a clear shift in the underpinning educational approach, from the OBE of the NCS, described as encouraging *'a learner-centred and activity-based approach'* (DoE, 2003, p 7), to the approach in the CAPS which is described as *'an active and critical approach to learning, rather than rote and uncritical learning of given truths'* (CAPS subject statements, 2011, p 4).In addition, the CAPS has narrowed its focus to a more clearly discipline-specific approach, with the exclusion of principles such as integration, portability and articulation, and with the re-establishment of subject boundaries (as evidenced by the omission of any discussion around the definition of the term 'subjects', and the omission of the NCS's stated intention of blurring of subject boundaries).

There has also been a shift from the strong focus on group-work that the NCS adopted, to a focus on the learner taking individual responsibility for his/her learning, as evidenced by the inclusion of the clause 'work as individuals' in the description of the type of learner envisaged (CAPS subject statements, 2011, p 5).

Where the NCS explicitly states the teacher's role as being (amongst other roles) the interpreter and designer of learning programmes and associated classroom activities, the design of the CAPS curriculum shifts this role, since the CAPS is itself a pre-designed learning programme, with prescriptive classroom activities. This, together with the silence in the introductory pages of the CAPS regarding the teacher, suggests that the role that the teacher plays has become greatly diminished in the CAPS. The implication is that teachers operate at the level of implementers of a predetermined learning programme, rather than having much flexibility in the design and adaptation of this learning programme to the varying needs of learners.

The findings of the Ministerial Task Team, laid out in the DoE Report (2009), showed that the expectation that teachers design their own learning programmes was strongly resisted by teachers and other respondents. Instead, the suggestion was that a more clearly structured teaching plan be provided to enable teachers to 'devote their energy to delivering quality instruction' (p 19). In this sense, the CAPS satisfies the recommendations made in the report.

The findings of the subject evaluation teams show that, for the majority of subjects, the content covered in the CAPS does not differ significantly in breadth or depth from the content in the NCS. Exceptions to this are the following subjects:

- **Mathematics:** The evaluation team found that the CAPS content exceeds that of the NCS in both breadth and depth, and is thus likely to be experienced as *'significantly more demanding than the NCS'*.
- **Life Sciences:** The evaluation team found that, although the curriculum content has been mostly repackaged in the transition from the NCS to the CAPS, there has been some reduction in both breadth and depth of the content in the CAPS.

Most of the evaluation teams concluded that the CAPS documents are an improvement over the NCS with regard to providing *'statements which are clear, succinct, unambiguous, measurable, and based on essential learning as represented by subject disciplines'*. Exceptions to this are the following subjects:

- **English FAL:** The content that is outlined in the content overview in the CAPS (p 10-48 of the English FAL CAPS) is very broad, and consequently has led to a set of teaching plans (pp 53-76 of the English FAL CAPS) which have not incorporated all of the content in the teaching time available. As a result, there is a difference between the topics which are included in the content overview and those represented in the teaching plans. This is likely to lead to confusion for teachers, and probable variations in interpretations of the curriculum.

- **English HL:** Although the evaluation team's overall comment on the CAPS was favourable, in that the *'core topics are fundamental to any course or syllabus intending to teach literacy, and include the development of writing, reading, listening and grammatical skills'*, the evaluation team indicated that the clarity of the guidance provided by the CAPS is undermined by the lack of guidance regarding the texts to be selected, and the relegation of the teaching of language structures and conventions to an appendix in the CAPS document, rather than integrating this as part of the teaching plan.

The move from OBE has also resulted in a shift from a cooperative, discovery-based learning, where the learner is a participant in the learning process, as a negotiator of meaning, to content-driven learning, where the learner is a recipient of a body of pre-determined knowledge.

Based on the findings of the subject evaluation teams, it can be concluded that the CAPS documents have a much more detailed level of specification of content than the NCS documents. A consequence of this increased level of specification is that there has been a shift in terms of the level at which the curriculum is aimed. According to the schema of curriculum levels discussed in the overview report, the NCS is set at the 'macro' level, since it focuses mainly around attainment levels, and the construction of the actual educational programme is left to the teacher, while the CAPS has shifted to the 'meso' level, and even, to some extent, the 'micro' level, in that its structure is that of an instructional programme, with a detailed description of content, sequencing and pacing.

# 2 LIFE SCIENCES PART 1: A COMPARISON OF NCS AND CAPS FOR THE FET PHASE


| | |
|---|---|
| **Evaluators** | Dr Edith Dempster<br>Ms Phumzile Majozi<br>Ms Prabha Pillay<br>Mrs Elizabeth Cilliers<br>Ms Susan Wiese<br>Ms Kathryn Johnson |


## 2.1 INTRODUCTION

### a) Characteristics of Life Sciences

Life Sciences (Biology) is a way of understanding natural phenomena involving living systems, based on empirical evidence. Life can be described as the result of interactions between the chemical substances that make up an organism. Life Sciences is the study of living systems at various levels of organisation. In ascending order of size and complexity, the levels of organisation used as a framing device for foundational biology are

1. molecules
2. cells
3. tissues
4. organs and organ systems
5. whole organisms
6. populations
7. communities
8. ecosystems
9. biomes
10. the biosphere.

Conceptual themes that stand outside these levels of organisation of life are systematics, the diversity of life, and evolution by natural selection. Biology was identified by Bernstein (1996, 1999) as an example of a discipline that exhibits a vertical knowledge structure, i.e., progresses from knowledge of independent facts/phenomena through progressively more inclusive concepts to a single unifying principle. Bernstein proposed that, as a vertical knowledge structure, Biology is powerful in its potential to raise cognitive skills through developing hierarchical thinking. Johnson *et al.* (2011) conceptualised the hierarchical knowledge structure of Biology in terms of the 'what', 'how' and 'why' of living phenomena; 'what' being descriptive, 'how' referring to the relationship between structure and functioning, and 'why' referring to evolution. Put another way, the lowest level of the hierarchy is the knowledge of individual facts, which are integrated into relationships between phenomena and their functioning, and ultimately reasoning about why phenomena and their functioning have come to be the way they are.

Johnson *et al.* (2011) depicted the discipline Biology in the form of a triangle, reproduced below.

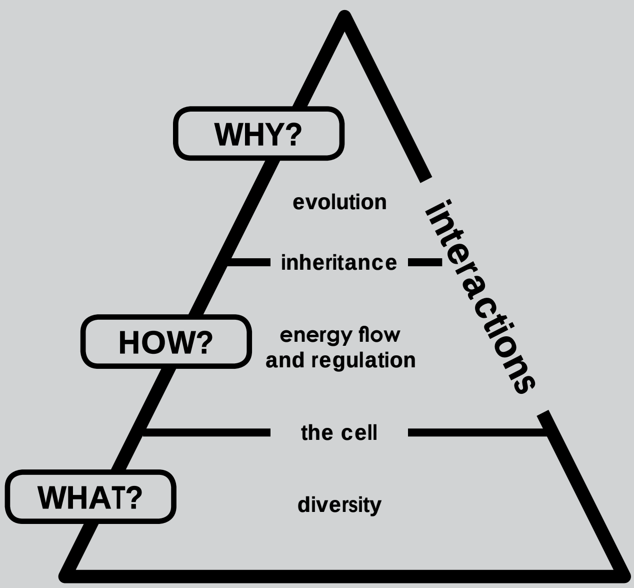


**Figure 1: Schematic representation of a hierarchical arrangement of the core concepts in biology (from Johnson et al. 2011)**

Johnson *et al.* (2011) describe the canonical knowledge of Biology as building upwards toward the highest ordering principle, which is evolution. 'What' questions form the base of the triangle, since they are concrete, and represented by the diversity of life forms that inhabit the world. Energy flow and regulation differentiates life from non-life, and occupies the 'how' level of the hierarchy. Regulation characterises metabolism, but requires energy, and this principle applies equally to life at cellular and whole organism level. The cell straddles both what and how, since it is more abstract than whole-organism diversity, but can be described in terms of what comprises a cell, as well as how it functions.

The highest order question is 'why', and this is characterised by the search for historical and evolutionary causes of phenomena. Inheritance straddles the 'how' and 'why' sections of the triangle because aspects of inheritance answer 'how' questions, but inheritance is also integral to evolutionary theory.

What science should be taught at school depends on the goals of the science curriculum. Roberts (1988, cited in Johnson *et al.*, 2011) responded to the question *'What counts as science education'* by saying that *'the answer is a defensible decision rather than a theoretically determined solution'* (p 30). Biology is more consistent in terms of its choice of content for study at school level than other science subjects, particularly the study of science at primary school level, which is very variable (Dempster *et al.*, 2013). Nevertheless, the tension between biology for everyday life and biology for future scientists plays a part in the selection of content for school biology in different countries. Ghana, for example, includes a large section on community health, sanitation and town planning (Umalusi, 2008) in its biology curriculum.

### b) Brief history of Life Sciences curriculum since 2003

In South Africa, the school subject Life Sciences emerged from the combination of two previously separate subjects, Biology and Physiology. To differentiate the new subject from the old subjects, it was called Life Sciences.

The NCS was published in 2003 (Doc 1.1). It was supplemented by Learning Programme Guidelines (Doc 1.2) and Subject Assessment Guidelines (Doc 1.3). The provincial subject advisors then developed an assessment syllabus for Grades 10 and 11, because the specification of content in the NCS (Doc 1.1) needed to be more detailed for use by teachers. These assessment syllabus documents were widely used, but were not official documents. The national DBE released Examination Guidelines for Grade 12 to specify content, sequencing and pacing, as well as the format of the National Senior Certificate examination papers to ensure that learners were adequately prepared for the National Senior Certificate in 2008.

The NCS was criticised for its lack of representation of the canonical structure of Biology (Dempster & Hugo, 2006), although other authors praised it for its humanistic approach (le Grange, 2008). In 2007, a new content framework (Doc 1.5) was released by the national DBE to replace the content in the NCS. This content framework was phased in in Grade 10 in 2009, and is known as **the NCS 2**[1] , whereas the previous curriculum was referred to as **the NCS 1**. New provincial assessment syllabi for Grades 10 and 11, and new national examination guidelines for Grade 12 were written and revised almost annually (Docs 1.6 and 1.7). The NCS 2 was first examined in the National Senior Certificate in 2011, but a large number of (mostly part-time) candidates wrote a separate examination based on the NCS 1 in 2011 and 2012. Circular E16 of 2010 (not included in the document pack) gave information regarding the format of the examinations for the NCS 2. The weighting of the Learning Outcomes (LOs) changed for the NCS 2, as well as the weighting of knowledge areas and cognitive levels.

Teams tasked with revising the curriculum were set up in 2009, which resulted in the release of the CAPS documents in 2011. The CAPS was implemented in Grade 10 in 2012, and will be examined in the National Senior Certificate in 2014. Examination guidelines are currently being written for Grade 12 by the national examiners and amendments to the CAPS document have already been issued, even before it is implemented in Grade 12 in 2014 (Circular S3 of 2013). Provincial subject advisors have developed work schedules to guide teachers in pacing the curriculum, and to provide assessment plans to structure formal and informal assessment.

[1] NCS 2: New Content Framework for Life Sciences Grades 10-12, phased in in 2007

The NCS 1 had an effective lifespan of five years, from its phasing in in Grade 10 in 2006 to its phasing out in Grade 12 in 2010. The NCS 2 also had an effective lifespan of five years, from its phasing in in Grade 10 in 2009 to its phasing out in Grade 12 in 2013. The CAPS is the third revision of curriculum content since 2006. Various assessment amendments have been implemented between the major curriculum revisions.

### c) The role of the subject in the FET Phase

Life Sciences is an elective in the FET Phase. It is not linked with any other subject. It is a 'gatekeeper' subject in the sense that access to science and science-related degrees at most universities requires a pass in either Physical Sciences or Life Sciences in the National Senior Certificate.

## 2.2 LIST OF DOCUMENTS ANALYSED

The evaluation team consulted seven documents relating to the NCS and three documents that define the CAPS. These are listed in Table 2. Each document was given a reference code which is used when referring to it throughout the rest of this report.

| **Table 2: Referenced documents** | |
|---|---|
| **1 National Curriculum Statement (NCS)** | |
| Department of Education. 2003. *National Curriculum Statement for Grades 10-12 (General): Life Sciences* | Doc 1.1 |
| Department of Education. 2008. *National Curriculum Statement for Grades 10-12 (General): Learning Programme Guidelines – Life Sciences* | Doc 1.2 |
| Department of Education. 2008. *National Curriculum Statement for Grades 10-12 (General): Subject Assessment Guidelines – Life Sciences* | Doc 1.3 |
| Department of Education. 2006. *National Curriculum Statement for Grades 10-12. Life Sciences. Teacher Training Manual* | Doc 1.4 |
| Department of Education. 2007 *A New Content Framework for Life Sciences in NCS Grades 10-12 (General)* | Doc 1.5 |
| Department of Education. 2009. *Life Sciences Examination Guidelines Grade 12* | Doc 1.6 |
| Department of Education. 2011. *Life Sciences Examination Guidelines Grade 12* | Doc 1.7 |
| **2 Curriculum and Assessment Policy Statement (CAPS)** | |
| Department of Basic Education. 2011. National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement ( CAPS ) Further Education and Training Phase Grades 10-12: Life Sciences | Doc 2.1 |
| Department of Basic Education. 2011. National Protocol for Assessment. Grades R – 12. | Doc 2.2 |
| Department of Basic Education. 2011. National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement. Grades R – 12 | Doc 2.3 |

## 2.3 BROAD CURRICULUM DESIGN, FORMAT AND USER-FRIENDLINESS OF CURRICULUM DOCUMENTATION

User-friendliness of the documents was rated as good, moderate or poor, based on a set of criteria[3].

Accessibility of the language used in each curriculum was rated as good, moderate or poor based on a second set of criteria[4].

Thereafter, the alignment between the various documents was rated as good, moderate or poor, based on yet another set of criteria[5].

The central design principle of the curriculum was identified.

| **Table 3: Broad design, format and user-friendliness** | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Number of documents (subject-related)** | 7 | 3 |
| **Total number of pages (in subject-related documents)** | 360 | 181 |
| **User-friendliness** | 1.1 Poor<br>1.4 Moderate<br>Other documents: Good | 2.1 Good |
| **Accessibility of language** | Good | Good |
| **Alignment** | Good | Good |
| **Central design principle** | Outcomes-based<br>Syllabus type<br>Competence curriculum | Syllabus-type<br>(Content-based)<br>Performance curriculum |

### NCS

Document 1.1 is the gazetted policy document for the subject Life Sciences. It defines the subject, outlines its scope and purpose, suggests some careers linked to Life Sciences, and outlines the LOs of the subject. It then provides the ASs for each LO. The LOs do not change by grade, but the ASs progress from one grade to the next. The proposed content and contexts used to achieve the ASs and LOs are sketched out very briefly on

3 **Good:** Very user-friendly - the function and the structuring of the documents is clear
**Moderate:** Moderately user-friendly - the function and the structuring of the documents is sometimes clear and at other times the function is unclear or the structuring confusing
**Poor:** Not user-friendly - the function and the structuring of the documents is often unclear or the structuring is overly complex

4 **Good:** Very accessible language - the documents use plain, direct language
**Moderate:** Moderately accessible language - the documents sometimes use plain, direct language and at other times the language is complex or obscure or terms are ill-defined
**Poor:** Inaccessible language - the documents often use complex or obscure language and terms that are not defined

5 **Good:** Good alignment - it is clear how documents relate to one another and complement one another
**Moderate:** Moderate alignment - it is sometimes clear how documents relate to one another; there are some contradictions across documents or there are instances where it is not clear how documents complement or relate to one another
**Poor:** Poor alignment - it is not clear how documents relate to one another. There are contradictions across documents, or how documents complement one another is not clear at all

pp 34-40 of the document. Assessment occupies chapter 4 of Doc 1.1. A comprehensive list of competence descriptors is provided In Doc 1.1, pp 50 – 61, where a description is provided of what a learner is able to do at each of the 6 levels of competence: level 6 being outstanding (80-100%), 5 being meritorious (60-79%), 4 being satisfactory (50-59%), 3 being adequate (40-49%), 2 being partial (30-39%) and 1 being inadequate (0-29%). The subject advisers on the team confirmed that the competence descriptors were never used in practice. A Glossary is provided at the end of the document (Doc 1.1).

Document 1.2 is the Learning Programme Guidelines (LPG), which is not policy. This document provides guidance to teachers on how to design a learning programme for Life Sciences. The stages in development of a learning programme are to develop a subject framework for the phase, followed by a work schedule for each grade, and then lesson plans for each lesson. Exemplars of work schedules for Grades 10 and 11 are provided. Teachers tend to rely on the content covered and its sequence in textbooks – especially in Grades 10 and 11 where there is no national examination. They rarely compare content covered in different textbooks. Learning Programme Guidelines were discussed when training took place initially, and panels of teachers used the document initially when designing work schedules, but the LPG was soon abandoned.

Document 1.3 is the Subject Assessment Guidelines (SAG), which provides guidelines for assessment generally, and in Life Sciences specifically. This document is also not policy. The subject assessment guidelines prescribe the number and type of assessment tasks, the weighting per LO, the allocation of knowledge area per examination paper, the weighting per topic in each examination paper, and the weighting per cognitive level. The format of the examination papers is also specified in the Subject Assessment Guidelines. Examples of different types of investigations with rubrics, and an example of a research project are provided. The SAG also defines what a task is e.g. an assignment and a project.

Document 1.4 is a teacher training manual that was used to introduce teachers to the NCS in 2006. The teacher training manual was not an official document, and was not used in this analysis.

Document 1.5 is the New Content Framework for Life Sciences that was released in 2007 for implementation in Grade 10 in 2009. This document was introduced because the content in the NCS Life Sciences (Doc 1.1) was deemed underspecified, and is commonly referred to as the NCS 2. Since Doc 1.1 is gazetted policy, Doc 1.5 does not replace Doc 1.1, but addresses particularly the under-specification of content. It provides a set of objectives for the subject, and a conceptual framework within which topics are located. The three LOs are re-phrased, but the ASs are not mentioned. The ASs listed in Doc 1.1 were not useful in structuring work schedules and lesson plans, as envisaged in Docs 1.1 and 1.2. They were used to structure examination questions, and textbook activities. The curriculum content in Doc 1.5 is organised according to the three LOs, and provides more comprehensive detail of the breadth and depth of topics to be studied than was provided for the NCS 1 (Doc 1.1).

Doc 1.6 is the official Examination Guidelines for 2009. This document was issued to clarify what should be taught, learned and assessed in Grade 12 only. The format of the examination papers is given, weighting per LO, weighting per cognitive level, and weighting per knowledge area. The content is elaborated and matched with LOs and ASs, and a detailed listing of content with a rough guide to pacing is provided.

Doc 1.7 is the official Examination Guidelines for 2011. Its purpose is the same as that of the Examination Guidelines 2009, but it now applies to the NCS 2 (Doc 1.5). Some changes were made to the allocation of knowledge areas to examination papers, the weighting of LOs, and weighting of cognitive levels. Content is rearranged from Doc 1.5 into a single list, without reference to LOS. This makes it difficult for teachers to set assessment tasks that have the requisite weighting per LO. They would have to refer to Doc 1.5 as well as Doc 1.7.

In addition to the official documents listed above, various Circulars have been distributed, which address problem areas that arise as the documents are implemented. A significant example is the Assessment Syllabus for Grades 10 and 11, which was developed by KwaZulu-Natal province and shared with other provinces. The Assessment Syllabus was the equivalent of the national Examination Guidelines (Docs 1.6 and 1.7). It provided a work schedule for teachers to follow.

Document 2.1 is the Curriculum and Assessment Policy Statement (CAPS) for Life Sciences, published in 2011. It consists of a General Introduction to the CAPS (pp 3-7), an Introduction to Life Sciences (pp 8-21), including three Specific Aims (SAs) of the subject, the time allocation, and resources required to teach the subject. This is followed by the content (pp 22 – 65) organized by Grade, and then knowledge area. The final section is on Assessment (pp 66 – 76). Document 2.1 therefore incorporates material from Documents 1.1, 1.3, 1.5, and 1.7 of the NCS 1 and NCS 2.

Document 2.2 is a policy document, dated 2011, that provides the national protocol for assessment from Grades R – 12. This is a generic document that stipulates the recording and reporting processes that should be followed by all schools in the Department of Basic Education. It covers record-keeping, as well as assessment policy for internal and external assessment.

Document 2.3, dated 2011, is a policy document stipulating programme and promotion requirements of the NCS. This document informs teachers about the structure of the educational programmes they offer in each phase, and the requirements for a learner to progress. It also sets restrictions on the number of times a learner may repeat a grade within each phase.

## User-friendliness

The user-friendliness of the **NCS** documents was generally judged to be good by the team.

Doc 1.1 was judged to be poor because it separated the LOs, ASs (pp 16 - 31) and content (pp 34 - 40). The content gave a list of topics with very little detail (pp 34 – 40). The content was replaced by Doc 1.5, beginning in Grade 10 in 2009.

Doc 1.2 was evaluated as good because LOs and ASs are arranged per grade to show progression across grades (pp 19 - 20). The content is elaborated with time allocation indicated per topic (pp 23 - 42).

Doc 1.3 was evaluated as good because the programme of assessment for each grade is given (pp 8 - 11). All requirements are clearly stated, e.g. Table 3.1 (p 8) gives the number of suggested tasks for the programme of assessment in Grades 10 and 11, with the weighting of each component. The weighting per knowledge area and cognitive level is specified in detail for the examination papers (pp 10 - 11). Examples of assessment tasks are provided (pp 21 - 25).

Doc 1.4 was evaluated as moderate because it was difficult to follow with many activities. Provinces had to restructure the document according to their needs for teacher workshops.

Doc 1.5 was evaluated as good, since content is specified per topic in each grade and allocated to the different LOs (Doc 1.5, pp 10 - 35). However, no time allocation is indicated.

Doc 1.6 and 1.7 were judged to be good. The format of the Question papers (Doc 1.6, p 3; Doc 1.7, p 2) is outlined. Weighting of the LOs, cognitive levels (Doc 1.6, p 2; Doc 1.7, p 2) and knowledge areas (Doc 1.6, p 4; Doc 1.7, p 2) is given. LOs and ASs are elaborated for the NCS 1 (Doc 1.6, pp 5 - 8), but only LOs are weighted (Doc 1.6, p 4; Doc 1.7, p 2). The content is elaborated, and sequencing and time allocation is stated (Doc1.7, pp 9 - 26; Doc 1.7, pp 3 - 27). Doc 1.7 includes a year planner (p 3).

The user-friendliness of the CAPS for Life Sciences (Doc 2.1) was evaluated as good. The structure and functioning of the document is clear. Skills are listed under SAs and each one is explained (Doc 2.1, pp 15 - 16). The content is arranged sequentially and elaborated with time allocation. Investigations are clearly listed for each topic (Doc 2.1, pp 22 - 65). The assessment requirements are clearly outlined (Doc 2.1, pp 68 - 70). The weightings of cognitive levels are stipulated (Doc 2.1, p 67). The content and its respective weighting tested per paper in all grades is listed (Doc 2.1, pp 71 - 73).

The content in the Grade 12 CAPS is arranged in a logical and meaningful sequence e.g. genetics is studied after DNA and Human Reproduction since it requires an understanding of the prior topics to understand genetic mechanisms.

Doc 2.2 gives clear and detailed guidelines about assessment, record-keeping and reporting at teacher and school level. Doc 2.3 gives clear guidelines about learning programme structure and promotion requirements.

### Accessibility of language

The language used in both the NCS and the CAPS was judged as good and accessible. Subject-specific terminology is used. The documents are available immediately in Afrikaans as well as English, and by request, in the other official languages of South Africa.

### Alignment

Alignment between the different NCS documents is moderate. The centrality of LOs and ASs outlined in the policy document (Doc 1.1) was partially carried through into the design of learning programmes, and an attempt was made through the examination guidelines for Grade 12 to align assessment with the ASs (Doc 1.6).

The ASs disappeared in the NCS 2 (Doc 1.5) and the Examination Guidelines for the NCS 2 (Doc 1.7). Each document in the sequence NCS 1 (Doc 1.1) to Learning Programme Guidelines (Doc 1.2) to Examination Guidelines (Doc 1.6) gave different levels of detail of the content, and added some content. Likewise, during the re-contextualisation of the NCS 2 (Doc 1.5) into Examination Guidelines (Doc 1.7), the content was re-structured, so that more detail was added, but the distinction between the LOs was lost. The order of knowledge areas was changed from that recommended. Each document is a re-contextualisation of a previous document, and it is not clear whether it replaces previous documents, or is to be used in conjunction with previous documents.

The weightings given in the Subject Assessment Guidelines (Doc 1.3) were subsequently changed in the Examination Guidelines, and the Examination Guidelines themselves changed between 2009 (Doc 1.6) and 2011 (Doc 1.7). The Examination Guidelines expanded the content so that it was more detailed than the LPG and the NCS 2. Subject advisors and teachers experienced the examination guidelines as more compact and user-friendly than the previous documents.

For the CAPS, there is only one subject-specific document. However, according to Circular S3 of 2013, an examination guidelines document will be released by the national DBE later in 2013. This document will provide more detail about the examined curriculum for Grade 12. The national exams directorate has set and moderated exemplar tasks for the school-based assessment. They are ready to be distributed by the DBE to the provinces.

The NCS for Life Sciences is a good example of the following quote from the Report of the Task Team for the Review of the implementation of the NCS (2009): *'There is a plethora of* *policies, guidelines and interpretations of policies and guidelines at all levels of the education system, from the DOE down to provincial, district and Subject Advisor level. ..... Discrepancies in and repetition of information in the different National Curriculum Statement documents (especially the National Curriculum Statement; Learning Programme Guidelines; and Subject Assessment Guidelines) must be resolved (p 7)'.*

Life Sciences is a particularly complex example, since the content was revised in 2009 (Doc 1.5), which did not replace the Policy document (Doc 1.1), but resulted in new Examination Guidelines (Doc 1.7) and province-based assessment syllabus documents.

The recommendation made by the Task Team (2009) was to: *'...develop one Curriculum and Assessment Policy document ..... that will be the definitive support for all teachers and help address the complexities and confusion created by curriculum and assessment policy vagueness, lack of specification, document proliferation and misinterpretation* (p 8)'.

This recommendation is already being undermined by Circular S3 of 2013, which indicates that the single CAPS document will be re-contextualised into Examination Guidelines.

### Central Design Principle

The NCS as a whole was an **outcomes-based** curriculum because it placed outcomes at the centre of the curriculum. Content was then selected to achieve the outcomes, and assessment was structured to evaluate learners' progress towards the outcomes (Docs 1.1 – 1.7). This is consistent with Tyler's **objectives** approach to curriculum (Tyler, 1982; Posner, 1998). According to Bernstein's classification of curricula, the NCS is a **competence-based curriculum** which requires learners to be active, creative and regulate their own learning (Bernstein 1990, 1996). In the NCS 1, the content had weak boundaries, as evidenced by the inclusion of a substantial amount of content related to human diseases, and indigenous knowledge. Stronger subject boundaries were evident in the NCS 2 than the NCS 1 (Johnson *et al.*, 2011).

Using Bernstein's classification, the CAPS is a **performance** curriculum where learners have to perform well in order to progress, and where knowledge is organised into different subjects taught independently of each other (Bernstein 1990, 1996). Although the CAPS states three SAs, these do not inform the choice of content and are not mentioned in assessment. Thus the CAPS curriculum is classified as a **syllabus** type curriculum, which is content-based.

The central design principle has been radically changed between the NCS and the CAPS. Where the intended curriculum for the NCS was clearly outcomes-based with horizontal demarcation of knowledge in the NCS 1 (Doc 1.1), the NCS 2 is still outcomes-based, but it has strong vertical organisation of knowledge (Johnson et al., 2011). The CAPS is a syllabus-based performance curriculum, with vertical organisation of knowledge.

## 2.4 CURRICULUM OBJECTIVES

Subject-specific aims/objectives are given in two main forms in the introductory section of each document: as a list (Doc 1.5, p 4; Doc 2.1, pp 8 - 9) (compared in Table 4), and in the form of three LOs in the NCS 2 (Doc 1.5, p 7), equivalent to the three SAs in the CAPS (Doc 2.1, pp 13 - 20) (compared in Table 5).

**Table 4: Subject-specific aims/objectives of the curricula**

| Objectives | NCS 2 (Doc 1.5, p 4) | CAPS (Doc 2.1, pp 8-9) |
|---|---|---|
| 1. Develop knowledge of core concepts, processes, systems and theories | Y | Y |
| 2. Devise and evaluate scientific investigations | Y | |
| 3. Know about the nature of science, its benefits and limitations | Y | |
| 4. Critically evaluate validity/credibility of scientific investigations, practices, issues and articles presented in popular media | Y | Y |
| 5. Identify ways in which biotechnology and biological knowledge have benefited humans | Y | Y |
| 6. Identify ways in which humans have harmed the environment | Y | Y |
| 7. Appreciate South Africa's unique biodiversity and the need to conserve it | Y | Y |
| 8. Know about the contributions of South African scientists | Y | Y |
| 9. Develop academic and scientific literacy in order to read, talk about, write about biological processes, concepts, investigations | Y | Y |
| 10. Be aware of how to be a responsible citizen in terms of one's body and the environment | Y | Y |

**Table 5: Comparing Learning Outcomes (LOs) and Specific Aims (SAs) of the curricula**

| | NCS 2 LOs (Doc 1.5, p 7) | CAPS SAs (Doc 2.1, pp 13-19) |
|---|---|---|
| **LO 1/ SA 2** | Investigating phenomena in Life Sciences | Investigating phenomena in Life Sciences |
| **LO 2/ SA 1** | Constructing Life Sciences knowledge | Knowing Life Sciences |
| **LO 3/ SA 3** | Applying Life Sciences in society | Appreciating and understanding the history, importance and applications of Life Sciences in society |

### Discussion

In general, the lists of objectives in the two curricula (Table 4) are very similar. In several places the wording is almost identical, for example: i) *'[develop] knowledge of core biological concepts, processes, systems and theories'* (Doc 1.5, p 4) and *'[develop] knowledge of key biological concepts, processes, systems and theories'* (Doc 2.1, p 8); ii) *'[develop] a level of academic and scientific literacy that enables learners to read, talk* *about, write about, and construct diagrams that illustrate biological processes, concepts and investigations'* (Doc 1.5, p 4), and *'[develop] a level of academic and scientific literacy that enables [learners] to read, talk about, write and think about biological processes, concepts and investigations'*(Doc 2.1, p 9).

The lists differ significantly in terms of two objectives only. Firstly, the CAPS lacks the objective relating to devising scientific investigations. The omission appears significant in that this objective (often referred to as 'doing science') is typically regarded as one of the core objectives of a science curriculum; however, it forms SA 2: *'Investigating phenomena in Life Sciences'* (Doc 2.1, p 15) and is elaborated on in detail on pp 15-17.

The second difference is that the list in the CAPS omits Objective 3 of the NCS 2, related to *'the nature of science'*. This particular phrase is a rich concept in science education, incorporating several aspects such as how scientific knowledge progresses, the role of evidence and peer review; the tentative, contested nature of scientific knowledge, and the limits of science. Nevertheless, while this phrase is missing from the objectives and SAs in the CAPS, it appears in the content specifications for Grade 10 (Doc 2.1, p 22) and provides the paradigm for the sub-section 'How Science Works' on the same page. The section 'Orientation to Life Sciences' in the CAPS (Doc 2.1, p 22) adds to the 'nature of science' in the form of the new sentence *'The nature of science: science involves contested knowledge, and non-dogmatic inferences based on evidence and peer review'.* In the main body of the curriculum, however, the phrase 'nature of science' occurs only once, and 3 times in the NCS 2. LO 3 in the NCS 2 allows more opportunities for a consideration of the nature of science. Individual teachers' understanding will determine the depth with which teachers carry this theme through the curriculum.

The LOs of the NCS 2 were essentially the same as those in the NCS 1 (Doc 1.1, p 7), with slight modifications to their wording and in their elaboration. When the three LOs of the NCS 2 (Doc 1.5) are compared with the three SAs of the CAPS (Table 5), however, a number of more significant differences are evident, both in their wording and in their elaboration. The most immediately obvious is that LO 1 in the NCS - *'Investigating phenomena in the life sciences'* – has become SA 2 in the CAPS. An apparent primary focus on developing practical, enquiry-based, investigative skills in the NCS has been replaced by knowledge acquisition in the CAPS.

Differences in the wording of LO 2 and its equivalent, SA 1, are also revealing. The NCS 1 was framed according to a strongly constructivist approach, as evidenced in the following elaboration of LO 2: *'This...involves the construction of knowledge... through learners collecting information and experiences from the world around them and linking these with their previous experiences (recognition of prior learning)'* (Doc 1.1, p 12). Constructivist language is also evident in the wording of LO 2 in the NCS 2: *'Constructing life sciences knowledge'*, and its elaboration: *'The learner is able to demonstrate construction, acquisition, understanding and application of life sciences facts and concepts...'* (Doc 1.5, p 7). SA 1 of the CAPS, however, avoids using the word 'constructing' or 'construction' in relation to knowledge altogether; instead, the aim 'knowing life sciences' has been broken down into the following components: Acquiring knowledge, understanding and making connections between ideas and concepts to make meaning of life sciences, applying knowledge in new and unfamiliar contexts, and analysing, evaluating and synthesising knowledge, concepts and ideas. The wording makes it clear, though, that knowledge acquisition is viewed as the responsibility of the learners; the role of the teacher is mentioned only in the context of assessment.

Finally, there are some significant differences in the elaborations of LO 3, particularly when all three curricula are compared. In the NCS 1, the elaboration of LO 3 emphasises the historical, contextual, tentative and contested nature of 'western science', the need for an awareness of *'different viewpoints in a multicultural society'*, and the need to 'rediscover' indigenous knowledge (IK) *'for its value in the present day'*. The dominant message seems to be that *'all forms of scientific knowledge need to be explored and critically evaluated'* (Doc 1.1, pp 12 - 13), in other words, that IK and *'western science'* are equivalent forms of scientific knowledge. In the NCS 2, LO 3 is elaborated as *'the history of some scientific discoveries, the nature of science, how indigenous knowledge relates to living systems'* and also mentions applications of life sciences in industry, careers, and in everyday life (Doc 1.5, p 7). In other words, while IK is still incorporated, the focus on it has been reduced.

This shift continues into the CAPS SA 3, where the sentence *'one of the differences between modern science...and traditional, indigenous knowledge systems is that they have their origins in different world views'* (Doc 2.1, p 17), emphasises the difference between science and IK, rather than equivalence. Apart from this, the elaboration of SA 3 is similar to that of LO 3 in the NCS 2 in its approach to the history of scientific discoveries and its relevance to the learners in terms of their everyday life and career opportunities.

## 2.5 CONTENT / SKILL COVERAGE: BREADTH AND DEPTH

**Content breadth** is defined as the number of topics represented in the curriculum for a specific subject. The content in the NCS 2 and the CAPS was organised according to four knowledge areas:

1. Life at the cellular, molecular and tissue level;
2. Life processes in plants and animals;
3. Environmental studies;
4. Diversity, change and continuity (Doc 1.5, p 3)

The first three knowledge areas correspond to the levels of organisation of living systems, while the fourth is an overarching and integrating theme.

The NCS 2 includes all four knowledge areas in each grade, while the CAPS has departed from that format. Thus, in Grade 11, there is no content ascribed to Knowledge Area 1;

although photosynthesis and cellular respiration are components of cell biology, they are categorised here as belonging to Life Processes in plants and animals. In Grade 12 there is no content related to Knowledge area 4, although the topic ‘Human impact on the environment’, taught and examined in Grade 11, is also examined in Grade 12.

### 2.5.1 Coverage (Breadth)

A generic list of content was compiled using the headings and sub-headings from a general-purpose Biology textbook for college non-majors. The reference textbook used was Starr, Evers and Starr (2010): *Biology Today and Tomorrow with Physiology Second Edition.* The generic list was supplemented and reorganised to reflect the usual organisation of a school biology curriculum. This usually involves providing more opportunities for inclusion of everyday knowledge and local knowledge.

Content topics in the NCS 2 and the CAPS were then ‘chunked’ into conceptually coherent ‘chunks’ and numbered. The NCS 2 is arranged by LOs, so content listed under LO2 and LO3 was included in the tally. The CAPS content integrates SA1 and SA 3 under the ‘Content’ column. ‘Chunks’ were assigned to the generic topics by all six members of the group, or by three group members once the criteria for assigning the chunks to topics had been established.

If a topic was present in the curriculum for a Grade, a ‘Y’ was entered in Table 6. A ‘Y’ does not reflect the size or complexity of a chunk. It merely indicates that the generic topic was included in the curriculum. Total number of topics included in each grade were than calculated as the total number of ‘Y’s for that grade. The total number of topics covered in the phase was calculated by counting each row in which a ‘Y’ appeared, regardless of which grade it appeared in. Thus the total number of topics for the phase is not the sum of the totals per grade, because some topics appear twice or three times in the phase.

**Table 6: Content coverage**

| Generic topics | NCS 2 | | | CAPS | | |
|---|---|---|---|---|---|---|
| | Gr 10 | Gr 11 | Gr 12 | Gr 10 | Gr 11 | Gr 12 |
| **A. Nature and history of science** | Y | Y | Y | Y | | Y |
| **Totals** | 1 | 1 | 1 | 1 | 0 | 1 |
| **B. Molecular and cell biology** | | | | | | |
| B1. Molecules of life | Y | | | Y | | |
| B2. Cell structure | Y | | | Y | | |
| B3 Energy and metabolism | Y | | | Y | | |
| B4 Capturing energy | Y | | | | Y | |
| B5 Releasing energy | Y | | | | Y | |
| **Totals** | 5 | 0 | 0 | 3 | 2 | 0 |

| Table 6: Content coverage (continued) | | | | | | |
|---|---|---|---|---|---|---|
| **Generic topics** | **NCS 2** | | | **CAPS** | | |
| | **Gr 10** | **Gr 11** | **Gr 12** | **Gr 10** | **Gr 11** | **Gr 12** |
| **C Genetics and Heredity** | | | | | | |
| C1 DNA structure and function | | | Y | Y | | Y |
| C2 Gene expression and control | | | Y | | | Y |
| C3 Cellular reproduction | Y | | Y | Y | | Y |
| C4 Patterns of inheritance | | | Y | | | Y |
| C5 Biotechnology | Y | | Y | Y | | Y |
| **Totals** | 2 | 0 | 5 | 3 | 0 | 5 |
| **D Evolution and Diversity** | | | | | | |
| D1 Evidence of evolution | Y | Y | Y | Y | | Y |
| D2 Biodiversity and classification | Y | Y | | Y | | |
| D3 Processes of evolution | | | Y | | | Y |
| D4 Diversity of bacteria, protists, fungi and viruses | Y | Y | | | Y | |
| D5 Plant diversity and evolution | | Y | | | Y | |
| D6 Animal diversity and evolution | | Y | Y | | Y | Y |
| **Totals** | 3 | 5 | 3 | 2 | 3 | 3 |
| **E Ecology** | | | | | | |
| E1 Population ecology | | | Y | | Y | |
| E2 Communities and ecosystems | Y | Y | Y | Y | Y | |
| E3 The biosphere | Y | | | Y | | |
| E4 Human effects on the environment | Y | Y | Y | Y | Y | |
| **Totals** | 3 | 2 | 3 | 3 | 3 | 0 |
| **F Life processes in animals** | | | | | | |
| F1 Animal tissues and organs | Y | Y | | Y | | |
| F2 Skeleton and muscles | | Y | | Y | | |
| F3 Circulation | | Y | | Y | | |
| F4 Gaseous exchange | Y | | | | Y | |
| F5 Immunity | | Y | | | Y | |
| F6 Digestion and nutrition | Y | | | | Y | |
| F7 Excretion | | Y | | | Y | |
| F8 Nervous control and the senses | | | Y | | | Y |
| F9 Endocrine control | Y | | Y | | | Y |
| F10 Reproduction and development | | | Y | | | Y |
| F11 Diseases, disorders and treatment in humans | Y | Y | Y | Y | Y | Y |
| F12 Homeostasis | Y | Y | Y | | Y | Y |
| **Totals** | 6 | 7 | 5 | 4 | 6 | 5 |
| **G Life processes in plants** | | | | | | |
| G1 Plant tissues and organs | Y | Y | | Y | | |
| G2 Transpiration & translocation | | Y | | Y | | |

| Table 6: Content coverage (continued) | | | | | | |
|---|---|---|---|---|---|---|
| **Generic topics** | **NCS 2** | | | **CAPS** | | |
| | **Gr 10** | **Gr 11** | **Gr 12** | **Gr 10** | **Gr 11** | **Gr 12** |
| G3 Reproduction and Development | | | Y | | Y | |
| G4 Responses to the environment | | | Y | | | Y |
| G5 Human uses of plants | | Y | Y | | Y | Y |
| **Totals** | 1 | 3 | 3 | 2 | 2 | 2 |
| **H Indigenous knowledge** | | | | | | |
| | Y | Y | | Y | Y | |
| **Totals** | **1** | **1** | **0** | **1** | **1** | **0** |
| **I Relationship to work** | | | | | | |
| | Y | Y | | Y | | |
| **Totals** | **1** | **1** | **0** | **1** | **0** | **0** |
| **J Ethics, attitudes and values** | | | | | | |
| | Y | Y | Y | Y | | |
| **Totals** | **1** | **1** | **1** | **1** | **0** | **0** |
| **U Unclassified** | | | | | | |
| | | | Y | | Y | |
| **Totals** | | | **1** | | **1** | |
| **Total number of topics** | **24** | **21** | **22** | **21** | **18** | **16** |
| **Total number of topics per phase** | **41** | **41** | | | | |

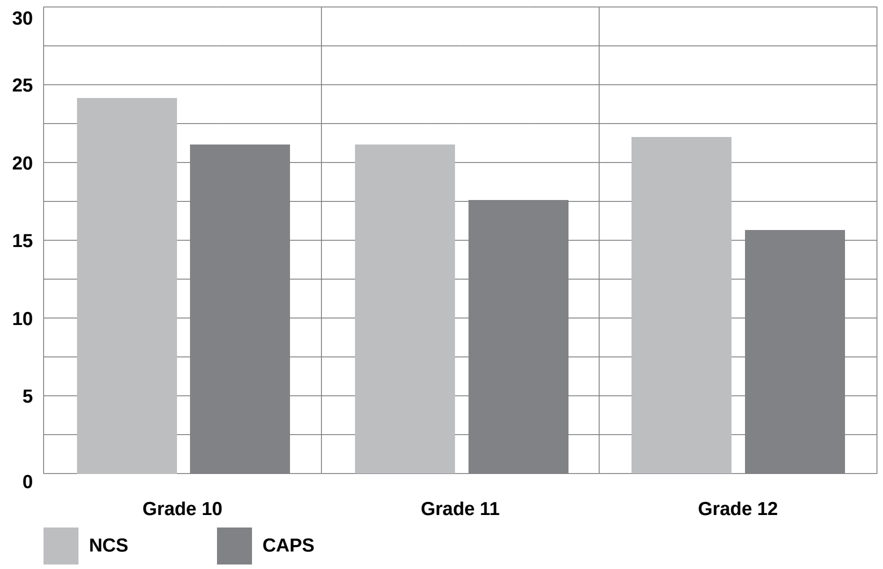


**Figure 2: Breadth of NCS and CAPS**

**Discussion:**

Both curricula include all the topics identified in the generic list of content. Both curricula therefore conform to the generally accepted range of topics included in a general-purpose Biology curriculum. Additions in both the NCS 2 and the CAPS are indigenous knowledge, ethics, attitudes and values, and relationship to work.

Table 6 and Figure 2 show that the NCS 2 has greater breadth than the CAPS at each grade and overall. The breadth of the NCS 2 is highest in Grade 10, decreases in Grade 11 and increases slightly in Grade 12. The breadth of the CAPS decreases from Grade 10 – 12.

**'Nature and history of science'** (A in Table 6) is included in each grade in the NCS 2, and in Grades 10 and 11 in the CAPS.

**'Molecular and cell biology'** (B1 – B5 in Table 6) is taught in Grade 10 only in the NCS 2 and in Grades 10 and 11 in the CAPS. The topics capturing energy (photosynthesis) and releasing energy (cellular respiration) have moved from Grade 10 to Grade 11 in the CAPS, and are listed in the knowledge area 'Life processes in plants and animals'.

**'Genetics and Heredity'** (C1 - C5 in Table 6) is taught in Grades 10 and 12 in the NCS 2 and in the CAPS. One topic, DNA structure and function, is mentioned briefly in the CAPS Grade 10. Genetics and heredity is omitted in Grade 11 in both curricula.

**'Evolution'** (D1 - D3 in Table 6) is taught in Grades 10, 11 and 12 in the NCS 2, while it is omitted in Grade 11 in the CAPS. Comparative anatomy as evidence of evolution is omitted in the CAPS, and biogeography as evidence supporting evolution is reduced and moved to Grade 10 as part of the history of life on earth.

**'Diversity'** (D4 - D6 in Table 6) is covered mainly in Grade 11 in both the NCS 2 and the CAPS, but the five kingdoms and their distinguishing characteristics are included in the NCS 2 Grade 10. Human evolution (D6) is included in Grade 12 in both curricula.

**'Ecology'** (E1 - E4 in Table 6) is taught in the NCS 2 Grades 10, 11 and 12, but only in Grades 10 and 11 in the CAPS. Human effects on the environment (E4) has been expanded in the CAPS and is taught in Grade 11, but examined again in Grade 12. Population and community ecology are treated separately in the NCS 2, but merged in the CAPS. This is a cause for concern, since the two levels of ecology, population and community, are separate sub-disciplines, with unique concepts and ways of investigation. The human effects on the environment include issues of global importance such as climate change, water, food security, loss of biodiversity, and solid waste disposal. These topics are also taught in Geography, but repeated in Life Sciences in the CAPS.

**'Life processes in animals'** (F1 - F12 in Table 6) are covered in Grades 10, 11 and 12 in both curricula. In the NCS 2, the sequence is gaseous exchange and digestion in Grade 10, musculoskeletal system, circulation, immunity and excretion in Grade 11, and nervous control, endocrine control and reproduction in Grade 12. Diseases, disorders and their treatments (F11) and homeostasis (F12) are incorporated in each grade. In the CAPS, the sequence has changed to musculoskeletal system and circulatory system in Grade 10, gaseous exchange, immunity, digestion and nutrition and excretion in Grade 11, and nervous control, endocrine control and reproduction in Grade 12. Diseases, disorders and their treatment are included in all grades, and homeostasis in Grades 11 and 12.

**'Life processes in plants'** (G1 - G5 in Table 6) is taught in all three grades in both curricula. Transpiration and translocation have moved from Grade 11 in the NCS 2 to Grade 10 in the CAPS, and reproduction and development from Grade 12 in the NCS 2 to Grade 11 in the CAPS.

**'Indigenous knowledge'** (H in Table 6) appears in Grades 10 and 11 in both curricula.

**'Relationship to work'** (I in Table 6) is mentioned in Grades 10 and 11 in the NCS 2 and Grade 10 only in the CAPS.

### Is the breadth appropriate for learners at this stage of their development?

Teachers experienced the NCS 2 as 'overloaded'. The CAPS is still 'overloaded' in Grades 10 and 11 according to teachers' experience, although the topics covered are a standard set of core biological knowledge and concepts included in most senior secondary curricula. The assessment requirements reduce teaching time, e.g. projects, more assessment required in the CAPS, early submission of marks, and time taken out of the teaching schedule for examinations twice a year, and three times in Grade 12. Time allocations are discussed in detail under 'Pacing'.

### Significant omissions or additions in either of the curricula

Overall, much the same content is covered in both curricula, but content has been moved between grades. The examination of Grade 11 subject matter in Grade 12 in the CAPS is an innovation and a challenge for textbook publishers. Overall, the breadth in each grade has been reduced between the NCS 2 and the CAPS, and decreases from Grade 10 to Grade 12, particularly in the CAPS. One significant change in the assessment in Grades 11 and 12 is that *'Human impact on the environment'* is now taught in Grade 11, as it was in the NCS 2, but examined again in Grade 12. In the NCS 2, *'Population and Community ecology'* was examined in Grade 12, while this is no longer the case in the CAPS. Ecology is a component of the disciplinary core, while human effects on the environment overlaps with Geography, and could be categorised as everyday knowledge. Its raised status in the CAPS is contentious.

## Skills

A list of skills of investigating and reasoning was compiled and is shown in Table 7 below. In Table 7, highlighted blocks indicate that the skill is not practised in that grade. Each activity in the column headed 'LO 1' in the NCS 2 (Doc 1.5) and 'Investigations' in the CAPS (Doc 2.1) was assigned to all the skills that were explicitly included in the description of the activity. Optional activities were not included in the tally. Thus a complex activity might be assigned to four or five skills, e.g. *'Determine the size of a population by quadrant or simple sampling, e.g. simulated mark/recapture. Collect and record data, interpret data, calculate/estimate the population size'* (Doc 2.1, p 49), would be assigned to skills A9, A11 and B1.

**Table 7: Number of times each skill is practised in each grade and curriculum**

| | | NCS 2 | | | Total | CAPS | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Gr 10 | Gr 11 | Gr 12 | | Gr 10 | Gr 11 | Gr 12 | |
| A Skills of investigating | 1. Identify characteristics or properties of specific organisms, materials and processes. | 6 | 9 | 11 | 26 | 15 | 10 | 7 | 32 |
| | 2. Use scientific instruments and equipment | 4 | 2 | | 6 | 6 | 3 | | 9 |
| | 3. Record observations appropriately, e.g. drawing, measurements, descriptions, counts | 4 | 2 | 3 | 9 | 10 | 4 | 1 | 15 |
| | 4. Compare / contrast | 1 | 2 | | 3 | | 1 | | 1 |
| | 5. Use hierarchical classification schemes | 3 | 2 | 1 | 6 | 2 | | | 2 |
| | 6. Dissection | 1 | 2 | 1 | 4 | 1 | 2 | 1 | 4 |
| | 7. Construct models or diagrams | 3 | 2 | 1 | 6 | 2 | 2 | 1 | 5 |
| | 8. Generate hypothesis / make predictions | | 1 | | 1 | | | | 0 |
| | 9. Follow instructions to carry out investigation | 4 | 2 | 4 | 10 | 4 | 5 | 2 | 11 |
| | 10. Design original investigation and carry out investigation | | 2 | | 2 | 1 | 3 | 2 | 6 |
| | 11. Collect data / represent data / interpret data | 9 | 7 | 5 | 21 | 9 | 11 | 2 | 22 |
| | 12. Draw conclusions based on the results | 3 | 3 | 2 | 8 | 6 | 5 | | 11 |
| | 13. Analyse data statistically | | | | 0 | | | 1 | 1 |
| | 14. Evaluate investigative procedures / models | 1 | | | 1 | | 1 | | 1 |
| | 15. Research a topic in books or other resources | 5 | 4 | 4 | 13 | 5 | 4 | 3 | 12 |
| | 16. Write a report / make a poster / present a talk | 1 | 2 | 4 | 7 | 3 | 2 | 2 | 7 |
| | **Total Investigating** | **45** | **42** | **36** | **123** | **64** | **53** | **22** | **139** |

| Table 7: Number of times each skill is practised in each grade and curriculum (continued) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NCS 2 | | | Total | CAPS | | | Total |
| | | Gr 10 | Gr 11 | Gr 12 | | Gr 10 | Gr 11 | Gr 12 | |
| B Reasoning | 1. Solve problems / find solutions | 1 | 1 | | 2 | | 4 | 7 | 11 |
| | 2. Convert information from one form to another, for example, table to graph, text to image, image to text | | 3 | | 3 | 1 | 1 | | 2 |
| | 3. Evaluate hypotheses, theories and models | | 1 | | 1 | | 1 | | 1 |
| | 4. Discuss or debate topical issues; support an argument with evidence | | 1 | 1 | 2 | | | 2 | 2 |
| | 5. Integrate / synthesize | | | 1 | 1 | | 2 | | 2 |
| | **Total reasoning** | **1** | **6** | **2** | **9** | **1** | **8** | **9** | **18** |

Skills of investigation were far more frequently practised than skills of reasoning, which occurred only once or twice in each grade, if at all. Figure 3 compares the skills of investigation in the CAPS and the NCS 2 for each Grade. Figure 4 compares the number of times each reasoning skill was practised in both curricula.

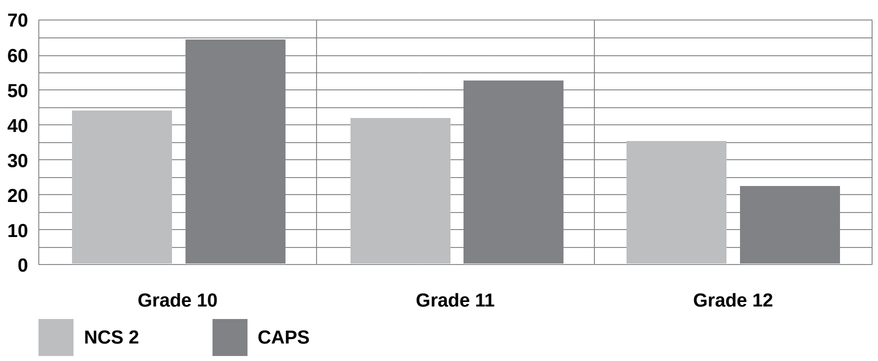


***Figure 3: Investigation - Number of times skills used per grade***

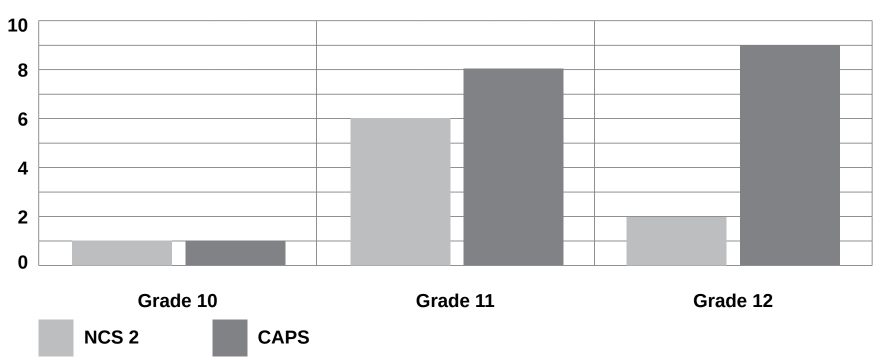


***Figure 4: Reasoning - Number of times skills used per grade***

### Discussion of skills

Overall, Figure 3 and Table 7 show that the CAPS provides more opportunities to practise skills of **investigating** than the NCS 2. In both curricula, the total number of times skills of investigation are practised declines from Grade 10 to Grade12, with the CAPS having a sharper decline than the NCS 2. The CAPS Grade 12 has only 22 skills, while the NCS 2 Grade 12 has 36 skills. This is related to the decrease in breadth of content in the CAPS Grade 12 (see Table 6).

Skill A1 is the most frequently practised skill in both NCS 2 and the CAPS. Being able to observe and identify organisms or structures is a core skill in Life Sciences. It is appropriate that it is practised frequently. However, learners are frequently required to observe objects, but recording their observations is much less frequently mentioned (Skill A3). '*Recording observations*' is an important skill in Life Sciences, encompassing drawing, measuring, counting, or writing verbal descriptions. Studying objects or organisms should be accompanied by some form of recording the observations.

Skill A11 is the second most frequently practised skill in both the NCS 2 and the CAPS. This skill involves collecting data and/or representing data and/or interpreting data. It is far more frequently practised than the preceding skill, which relates to conducting an investigation, either by following instructions (A9) or designing an original investigation (A10). Some activities require learners to analyse given data rather than generating their own data.

Thereafter, researching a topic in books or other resources (A15) is practised relatively frequently in both NCS 2 and the CAPS. Learners are not always required to produce something, e.g., a report or poster or oral presentation (A16) as a result of their research.

Skills of investigation that are omitted or under-represented in both curricula are comparing and contrasting (the basis of the hierarchical classification system), generating a hypothesis or making predictions, analysing data statistically (e.g., calculating summary statistics), evaluating an investigation or a model. The NCS 2 does not provide enough opportunity for learners to design and carry out their own investigations. The CAPS does not provide enough opportunity to use hierarchical classification systems, which is a key skill in biology.

Table 7 and Figure 4 show that reasoning skills are more comprehensively covered in the CAPS than in the NCS 2. In particular, solving problems or finding solutions are practised 11 times in the CAPS, compared with twice in the NCS 2. Other reasoning skills occur infrequently in both curricula, even skill B4 *('Discuss or debate topical issues; support an argument with evidence')*, which would align closely with the *'Human impact on the environment'* topic in Environmental Studies.

In conclusion, skills of investigating and reasoning are more comprehensively covered in the CAPS than in the NCS 2.

### 2.5.2 Depth

**Content depth** is defined as the complexity and extent of cognitive challenge associated with the topic. Each content topic, as defined in Table 5, was rated on a scale of 1-4, based on the complexity and the abstractness of the topic.

The scale was interpreted as follows:

**1** = Mostly single ideas and simple logical steps, related to everyday life and everyday language, few links between ideas, mostly deals with concrete objects.

**4** = Requires synthesis or evaluation of a number of individual ideas, related to scientific concepts and specialist language, mostly deals with abstract ideas rather than concrete objects or phenomena.

**2** and **3** were not defined, but were "leaning towards" either 1 or 4.

**Table 8: Depth of Content**

| | NCS 2 | | | CAPS | | |
|---|---|---|---|---|---|---|
| | Gr 10 | Gr 11 | Gr 12 | Gr 10 | Gr 11 | Gr 12 |
| **A Nature and history of science** | **4** | **4** | **4** | **3** | | **4** |
| **B Molecular and cell biology** | | | | | | |
| B1. Molecules of life | 2 | | | 2 | | |
| B2. Cell structure | 2 | | | 3 | | |
| B3 Energy and metabolism | 2 | | | 2 | | |
| B4 Capturing energy | 1 | | | | 2 | |
| B5 Releasing energy | 2 | | | | 3 | |
| **C Genetics and Heredity** | | | | | | |
| C1 DNA structure and function | | | 3 | 1 | | 2 |
| C2 Gene expression and control | | | 3 | | | 2 |
| C3 Cellular reproduction | 1 | | 2 | 2 | | 2 |
| C4 Patterns of inheritance | | | 3 | | | 3 |
| C5 Biotechnology | 2 | | 2 | 1 | | 2 |
| **D Evolution and Diversity** | | | | | | |
| D1 Evidence of evolution | 3 | 2 | 4 | 4 | | 3 |
| D2 Biodiversity and classification | 2 | 1 | | 2 | | |
| D3 Processes of evolution | | | 3 | | | 3 |
| D4 Bacteria, protists, fungi and viruses diversity | 1 | 2 | | | 2 | |
| D5 Plant diversity and evolution | | 3 | | | 2 | |
| D6 Animal diversity and evolution | | 4 | 2 | | 2 | 4 |
| **E Ecology** | | | | | | |
| E1 Population ecology | | | 3 | | 3 | |
| E2 Communities and ecosystems | 2 | 1 | 3 | 3 | 3 | |

| Table 8: Depth of Content (continued) | | | | | | |
|---|---|---|---|---|---|---|
| | NCS 2 | | | CAPS | | |
| | Gr 10 | Gr 11 | Gr 12 | Gr 10 | Gr 11 | Gr 12 |
| E3 The biosphere | 1 | | | 2 | | |
| E4 Human effects on the environment | 3 | 3 | 2 | 1 | 4 | |
| **F Life processes in animals** | | | | | | |
| F1 Animal tissues and organs | 2 | 3 | | 3 | | |
| F2 Skeleton and muscles | | 3 | | 3 | | |
| F3 Circulation | | 3 | | 3 | | |
| F4 Gaseous exchange | 3 | | | | 3 | |
| F5 Immunity | | 1 | | | 1 | |
| F6 Digestion and nutrition | 3 | | | | 3 | |
| F7 Excretion | | 2 | | | 3 | |
| F8 Nervous control and the senses | | | 3 | | | 2 |
| F9 Endocrine control | 2 | | 2 | | | 2 |
| F10 Reproduction and development | | | 3 | | | 3 |
| F11 Diseases, disorders and treatment in humans | 3 | 3 | 3 | 2 | 3 | 2 |
| F12 Homeostasis | 2 | 2 | 2 | | 2 | 2 |
| **G Life processes in plants** | | | | | | |
| G1 Plant tissues and organs | 2 | 2 | | 2 | | |
| G2 Transpiration & translocation | | 2 | | 2 | | |
| G3 Reproduction and Development | | | 4 | | 2 | |
| G4 Responses to the environment | | | 2 | | | 2 |
| G5 Human uses of plants | | 1 | 2 | | 1 | 1 |
| **H Indigenous knowledge** | **1** | **1** | | **1** | **1** | |
| **I Relationship to work** | **1** | **1** | | **1** | | |
| **J Ethics, attitudes and values** | **2** | **3** | **4** | **2** | | |
| **U Unclassified** | | | **1** | | **1** | |
| **Total topics at 1** | **6** | **6** | **1** | **5** | **4** | **1** |
| **Total topics at 2** | **12** | **6** | **8** | **9** | **6** | **9** |
| **Total topics at 3** | **5** | **7** | **9** | **6** | **7** | **4** |
| **Total topics at 4** | **1** | **2** | **4** | **1** | **1** | **2** |
| **Overall Depth Score** | **2,04** | **2,24** | **2,74** | **2,14** | **2,28** | **2,44** |

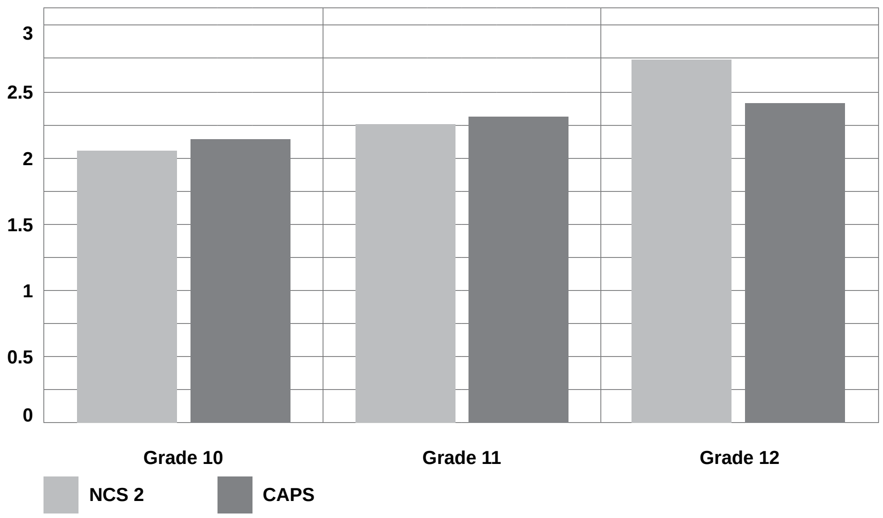


**Figure 5: Average depth of topics per grade**

## Discussion

The NCS 2 progresses from an average depth per topic of 2,04 in Grade 10 to a depth of 2,73 in Grade 12. The CAPS progresses from a depth of 2,14 in Grade 10 to a depth of 2,44 in Grade 12. Both curricula show increasing depth across the phase, but the depth of Grade 12 in the NCS 2 is considerably higher than the depth of Grade 12 in the CAPS.

Very few topics in both curricula were assigned a depth of 4, but more in the NCS 2 (7 topics) than in the CAPS (4 topics). The number of topics assigned a depth of 3 was 21 in the NCS 2 and 17 in the CAPS. At the opposite end of the scale, fewer topics were assigned a depth of 1 in the CAPS (10) than in the NCS 2 (13).

Overall, the shift from the NCS 2 to the CAPS has involved a reduction in the depth at Levels 3 and 4, and a reduction in the number of topics at a depth of Level 1. Overall, the CAPS has reduced the breadth and the depth of the NCS 2, especially at Grade 12 level. However, one topic from Grade 11, '*Human influence on the environment*', is examined in Grade 12. An analysis of the depth of the examined curriculum may yield a different result from the intended curriculum.

### 2.5.3 Specification of topics

**Curriculum specification** is the degree to which knowledge is broken down for stipulation in the curriculum. A set of codes[6] was used to make a judgement of each curriculum with regard to specification of topics.

| Table 9: Degree of specification of topics | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Degree of specification** | Medium | Medium |
| **Example 1** | Artificial selection mimics natural selection. Artificial selection as illustrated by at least one domesticated animal species and one crop species (Doc 1.5, p 34) | Artificial selection: ONE example of a domesticated animal and ONE example of a crop species (Doc 2.1, p 61) |
| **Example 2** | Homeostasis: Maintaining constant internal environment. General role of negative feedback in homeostasis drawing on glucose and carbon dioxide [Grade 10], water and salts [Grade 11]<br>Temperature regulation: Adaptations of human skin for thermoregulation – the effects of sweating, vasodilation and vasoconstriction (Doc 1.5, p 30) | Homeostasis: The process of maintaining a constant optimal internal environment.<br>• Negative feedback: Glucose, carbon dioxide, water and salts.<br>• Thermoregulation: Adaptations of human skin; sweating, vasodilatation, vasoconstriction(Doc 2.1, p 60) |

#### Discussion

The specification is very similar across the curricula. Given that the content had already changed in 2009, the curriculum developers were under pressure not to change much in the content, but to reduce it. The reduction in breadth and depth between the NCS 2 and the CAPS is evident in Table 6 and Table 8.

### 2.5.4 Comments on Content / Skill Coverage

#### Comparison of content and skills across the various curricula, and the appropriateness of these for the relevant age group

Content and skills have been compared in Section 8.2. Compared with international curricula, the content and skills required in the NSC are at a rather low level for an exit level qualification (Umalusi, 2010a).

6 **High:** High specification - extremely clear subject-specific specification: very little chance for multiple interpretations
**Medium:** Medium specification - moderately clear subject-specific specifications, some generic statements /skills or some topics underspecified
**Low:** Low specification - not clear subject-specific specification, minimal guidance provided for users and allows for multiple interpretations

### To what extent do the curricula provide clear, succinct, unambiguous, measurable statements of learning?

Both curricula would benefit from having the content stated as an objective, with a verb and a noun-phrase. A curriculum document is not a textbook, so there will always be a measure of ambiguity when the curriculum is interpreted by a textbook author or teacher. The lack of a verb indicating what learners are expected to be able to do with a particular item of content makes it difficult to say that statements are measurable, other than that they can recall that information. Investigations in both curricula often omit who is expected to do the prescribed activity, and how they should record their observations.

### To what extent are the curricula based on a strong, discipline-based approach to school subjects?

Both curricula have a strong discipline-based approach to the subject. The NCS 2 was constructed with vertical development of topics as a core, but this has been somewhat diluted in the CAPS in the evolution section, but strengthened in the Life processes knowledge area. For example, the development of the concept of evolution in the CAPS has lost its vertical development, in that comparative anatomy has been excluded, and diversity is not related to descent with modification of basic body plans. These concepts are essential foundations for understanding evolution by natural selection, which is taught in Grade 12. Thus Grade 10 exposes learners to the fossil record and biogeography, Grade 11 has a gap in establishing the evidence on which evolution is based, and Grade 12 presents evolution by natural selection.

*'Environmental Studies'* is another knowledge area where the discipline of biology has been diluted. The accepted name for this branch of biology is *'Ecology'*, but both the NCS 2 and the CAPS use *'Environmental Studies'*. The levels of organisation within an ecological system are (from largest to smallest): biome – ecosystem – community – population. This does not imply that the sequence is immutable: Most university courses teach Population ecology before Community ecology. The NCS 2 teaches biomes and ecosystems in Grade 10 and community and population ecology in Grade 12. *'Human impact on the environment'* is taught in Grade 11. The CAPS retains biomes and ecosystems in Grade 10, conflates community interactions with population ecology in Grade 11, and teaches human impact on the environment in Grade 11. The examined topics in the exit level examinations *('Human impact on the environment')* are everyday issues rather than substantive discipline-based knowledge and skills.

**Is the way in which the subject knowledge is presented in the curricula up-to-date with any shifts in the discipline itself?**

The way in which subject knowledge is presented is reasonably up-to-date, although the depth of the content is more superficial than is the case in other curricula at this level (Umalusi, 2010a). This impression will be explored further when the international comparison study is conducted.

The skills included in the curriculum are achievable if not fully up-to-date, including open-ended investigations as well as teacher-directed investigations. The non-availability of equipment at most South African schools severely limits the types of investigations that can be undertaken. Curricula at senior secondary level from developed countries assume that scientific equipment such as microscopes, data loggers, and computers are available, and they require learners to use statistical tests (Umalusi, 2010a). In South Africa, microscopes are not available in most schools, meaning that investigations requiring microscopes are always optional, and teachers can use micrographs or bio-viewer slide strips instead of direct observation of cells, tissues and micro-organisms.

**Erroneous, missing or inappropriate content**

There are a number of relatively minor issues around content and skills in both the NCS 2 and the CAPS.

- The content and concept progression for the CAPS (Doc 2.1, p 10) omits genetics, which is taught in Grade 12.
- The incorrect term '*modification by descent*' (Doc 1.5, p 34; Doc 2.1, p 61) which should be '*descent with modification*' is used in both the NCS 2 and the CAPS.
- The CAPS has interpreted the heading '*significance of seeds*' as being related to everyday life (Doc 2.1, p 40), omitting the significance of seeds in the evolution of plants. This heading was present but not explained in the NCS 2.
- The structure and functions of the components of blood is omitted in the CAPS (Doc 2.1, p 32).
- The CAPS presents a misinterpretation of the term '*organisms*' in the statement '*terrestrial and aquatic biomes of Southern Africa and how climate, soils and vegetation influence the organisms found in each.*' (Doc 2.1, p 33). Vegetation is composed of organisms, so the statement is incorrect.
- Many activities in the '*Investigations*' column of the CAPS do not state who (i.e. teacher or learner) should do the activity, e.g. 'obtain intestines of a sheep from a butcher and trace the passage that food will take' (Doc 2.1, p 43).
- '*Birth*' is omitted from the topic '*Human reproduction*' in the CAPS (Doc 2.1, p 56).
- At times, the CAPS states that some of the content and/or investigations are essential, but it is unclear whether activities not marked '*essential*' can be omitted.

## 2.6 CURRICULUM WEIGHTING AND EMPHASIS

### 2.6.1 Curriculum emphasis within the phase (Subject time allocation)

The research question addressed is: *'What topics are emphasised or form the focus of the curriculum?'*

| Table 10: Subject time allocation | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Total classroom time allocated for Life Sciences in the phase** | 4,5 h per week/ 29,5 h total teaching time per week (NCS Overview Document, p 21) | 4 h per week/ 27,5 h total contact time per week (Doc 2.1, p 7) |
| **% of total classroom time allocated for all subjects in the phase** | 15,2% | 14,8 % |

For the NCS, 15,2% and in the CAPS 14,8% of contact time per week is allocated to Life Sciences according to the NCS Overview Document and the CAPS (Doc 2.1, p 7)(see Table 10).

There is a contradiction in the documents because the Learning Programme Guidelines for the NCS state that the contact time for Life Sciences is 4 hours per week (Doc 1.2, p14). The time allocation for Life Sciences in the CAPS is slightly reduced from the NCS.

The CAPS also shows a reduced allocation for total teaching time from 29,5 h per week to 27,5 h per week. This is a significant change, if it is correct.

### 2.6.2 Curriculum emphasis within the subject (Topic Weighting)

The weightings were obtained by calculating the number of weeks a topic is recommended to be taught as a percentage of the total number of teaching weeks in a year. Topics were taken from the following documents:

- NCS 2: Doc 1.7, p 3 for Grade 12 only
- CAPS: Doc 2.1, pp 22 - 65

| Table 10: Subject time allocation | | | |
|---|---|---|---|
| | **Central topics** | **NCS 2** | **CAPS** |
| **Grade 10** | How science works | No time allocation given per topic in Doc 1.7 | 2 |
| | The Chemistry of Life | | 8 |
| | Cells: The basic unit of Life | | 9 |
| | Cell Division: Mitosis | | 6 |
| | Plant and Animal Tissues | | 9 |

| Table 10: Subject time allocation (continued) | | | |
|---|---|---|---|
| | **Central topics** | **NCS 2** | **CAPS** |
| | Organs | | 2 |
| | Support and Transport systems in Plants | | 9 |
| | Support systems in Animals | | 9 |
| | Transport systems in humans | | 9 |
| | Biosphere to Ecosystems | | 19 |
| | Biodiversity and Classification | | 3 |
| | History of Life on Earth | | 15 |
| **Grade 11** | Biodiversity and Classification of Micro-organisms | No time allocation given per topic in Doc 1.7 | 10 |
| | Biodiversity of plants and Reproduction in Plants | | 10 |
| | Biodiversity of animals | | 6 |
| | Energy transformations | | 14 |
| | Animal nutrition | | 10 |
| | Gaseous exchange | | 8 |
| | Excretion in humans | | 8 |
| | Population ecology | | 12 |
| | Human Impact on the Environment | | 22 |
| **Grade 12** | Nucleic acids | 8 | 9 |
| | Meiosis | 4 | 7 |
| | Genetics | 13 | 15 |
| | Evolution | 21 | 22 |
| | Plant responses | 4 | 4 |
| | Coordination- nervous and chemical, homeostasis | 21 | 23 |
| | Reproduction | 17 | 13 |
| | Population ecology | 8 | 0 |
| | Community structure | 4 | 0 |
| | Human Impact on the Environment | 0 | 7 |

### Discussion

- What is the emphasis in each curriculum in terms of the central topics covered?
- How does the weighting of topics compare across the curricula?

For Grades 10 and 11 in the **NCS 2**, no time allocations are given in Doc 1.5.

Provincial assessment syllabus documents were issued, which gave time allocations for Grades 10 and 11, and these were widely used, but differed between provinces. The Grade 12 Examination Guidelines (Doc 1.7) specified the weighting of topics for the whole country, and is shown in Table 6.

In the **CAPS**, the central topic in Grade 10 is *'Biosphere to Ecosystems'*(19%) and the *'History of Life on Earth'* (15%); in Grade 11 it is *'Human Impact on the Environment'* (22%).

For Grade 12 in the **NCS 2**, the central topics are *'Evolution and Co-ordination'* (21% each) and '*Reproduction*' (17%).

In the CAPS Grade 12, the central topics are '*Co-ordination*' (23%), and '*Evolution*' (22%). '*Reproduction*' is reduced to 13%.

In both curricula, the following topics carry more or less the same weighting: '*Nucleic acids*', '*Evolution*', '*Plant responses*', '*Genetics*' and '*Co-ordination*'. The CAPS shows an increase in the weighting for '*Meiosis*' (4% to 7%), and a decrease in weighting for '*Reproduction*' (17 to 13%). '*Population Ecology*' (8%) and '*Community structure*' (4%) have been removed from the CAPS for Grade 12 and have been replaced by '*Human Impact on the Environment*' (7%). In Grade 12, 2 weeks are allocated for revision of the topic.

## 2.7 CURRICULUM PACING

**Pacing** is defined as the rate at which content should be covered (in given time frames) over the course of a grade or phase.

The degree of **specification** of the pacing is judged by how clearly pacing is described in the curricula. Codes[7] were used to assess the curricula.

The **level of the pacing** is judged as how learners would experience the pacing of the curriculum, and pacing in the curricula was assessed using a set of codes[8].

| **Table 12: Pacing** | | |
|---|---|---|
| | **NCS 2** | **CAPS** |
| **Level of specification of pacing** | Low | High |
| **Rationale/justification** | No pacing provided for Grades 10 and 11. Year plan is provided for Grade12 (Doc 1.7,p 3) | Time allocation per topic indicated as well as the term in which the content should be covered. Provided for all grades. (Doc 2.1, pp 22 - 65). |
| **Level of pacing itself** | No pacing | Fast for Grades 10 and 11, moderate for Grade 12. |
| **Rationale/justification** | | Experience of teachers is that they have to rush through the curriculum to complete it in the year. However, pacing is uneven, i.e., too much time is allocated for some topics, and too little for others. |

7 **High:** Very clear and explicit stipulation - pacing is made very explicit through clearly stipulating what topics are to be covered in what time frame over the course of the grade
**Moderate:** There is a moderate/some degree of specification of pacing, providing broad parameters as to what should be covered over the course of the grade
**Low:** Pacing is left open to the discretion of the teacher and little or no indication is given of the rate at which content should be covered over the course of the grade beyond a specification of content per phase

8 **Fast:** The pace expected is too fast for learners at this level of development
**Moderate:** The pace is moderate, and is appropriate for learners at this level of development
**Slow:** The pace is too slow for learners at this level of development

### Specification of Pacing

A comparison cannot be made between Grades 10 and 11 for the CAPS and the NCS 2, because pacing is not prescribed in the curriculum documents for the NCS 2. Although assessment syllabi specifying the pacing were used in the different provinces in Grades 10 and 11 in the NCS 2, these documents did not originate from DBE and were therefore not used in this study. In the CAPS Grades 10 and 11, the total time allocated for teaching is 32 weeks out of the 40 weeks of the school year calendar (Doc 2.1, p 19). The balance of 8 weeks is allocated to examinations, tests and disruptions due to other school activities (Doc 2.1, p 19). In the CAPS, the specification of the pacing is very clear and explicit. Time frames are allocated per main topic, allowing teachers to pace their work so as to complete the syllabus over the course of the year.

In the NCS 2, Grade 12, a suggested year planner is provided, indicating only the topics per week and term without any detail on the content to be covered (Doc1.7, p 3). In the CAPS Grade 12, the total time allocated for teaching is 27½ weeks out of the 40 weeks of the school year calendar (Doc 2.1, p 19). The balance of 12½ weeks is allocated to examinations, tests and disruptions due to other school activities (Doc 2.1, p 19). In the CAPS, the specification of the pacing is very explicit. Time frames are allocated per topic, e.g. 'Responding to the environment: Humans' is allocated 4 weeks in total, but the pacing for each sub-topic is not given. The teacher thus has considerable freedom to determine the pacing within each topic to suit his/her class.

### Level of Pacing

In the NCS 2, the level of pacing is left to the teacher to determine, especially for Grades 10 and 11. In practice, the provinces constructed and distributed a work schedule which most teachers adopted. For Grade 12, the examination guidelines allocated a number of weeks for every broad topic, e.g. Three weeks for '*Genetics*', but no breakdown is given for the subsections (Doc 1.7, p 4). In the CAPS for Grades 10 to 12, the pacing is unevenly allocated, e.g. In Grade 10, only two hours is allocated for '*How science works*' compared to the two weeks allocated for '*Mitosis*' (Doc 2.1, pp 22, 26).

Due to systemic pressures, teachers find it difficult to complete the curriculum content, (both the NCS 2 and the CAPS) because more time is used for examinations than provided for in the policy documents. The level of pacing as experienced by teachers is too fast.

## 2.8 CURRICULUM SEQUENCING AND PROGRESSION

### 2.8.1 Specification of sequence

**Sequencing** is defined as the order in which topics are to be taught. The research question for sequencing asks for a judgement of the level of specification of sequencing. Since sequencing is closely related to progression, comments with regard to the appropriateness of the actual sequence followed are made in the section on progression.

Descriptors[9] were used to code the **degree of specification** of the sequencing for each of the curricula.

| Table 13: Specification of sequencing | | |
|---|---|---|
| | **NCS 2** | **CAPS** |
| **Level of specification** | Low | High |
| **Rationale/ justification** | The sequence of topics is recommended per grade. | The sequence of knowledge areas is recommended per term and per grade; within each knowledge area, the sequence is implied by the allocation of topics to terms, and the allocation of weeks to each topic. |

**Sequencing**

Sequencing in the NCS 2 is recommended per grade, but not within grades, as indicated by the following statement *'... educators have the freedom to expand concepts and to design and organise learning experiences according to their local circumstances'* (Doc 1.5, pp 5 - 6). Teachers are instructed to address all four knowledge areas in each grade (Doc 1.5, p 6). A **recommended** sequence is given for each grade (Doc 1.5, p 6), and is shown in Table 14.

| Table 14: Recommended sequence of knowledge areas in the NCS 2 | | | |
|---|---|---|---|
| **Sequence** | **Gr 10** | **Gr 11** | **Gr 12** |
| **1** | Environmental studies | Life processes in plants and animals | Environmental studies |
| **2** | Diversity, change and continuity | Life at the molecular, tissue and cellular level | Life processes in plants and animals |
| **3** | Life at the molecular, cellular and tissue level | Diversity, change and continuity | Life at the molecular, cellular and tissue level |
| **4** | Life processes in plants and animals | Environmental studies | Diversity, change and continuity |

9 **High:** Highly specified sequence - the order in which topics are to be taught is clearly specified and prescribed within and across grades
**Moderate:** Moderately specified sequence - there is a general suggested order in which topics are expected to be taught within and across grades, but allowance is made for some discretion on the part of the teacher
**Low:** Sequencing is not prescribed within and/or between grades

However, the examination guideline changed the sequence for Grade 12 to Knowledge areas 3 and 4 first, then Knowledge area 2 and finally Knowledge area 1. This sequence was also followed by the examination papers, with Paper 1 examining Knowledge areas 3 and 4 and Paper 2 examining Knowledge areas 1 and 2.

The rationale for the original recommended sequence for the NCS 2 was an attempt to teach environmental studies in the spring and summer terms, since this is when the environment is most active (Doc 1.5, p 6). However, teachers were advised to teach cellular and molecular biology before '*Life processes in plants and animals*', because cell biology is foundational to understanding the structure and functioning of whole organisms (Doc 1.5, p 6). In Grades 11 and 12, the suggested sequence of the four knowledge areas was intended to allow for conceptual progression within and between the knowledge areas and between grades, culminating in the theory of evolution by natural selection.

The **CAPS** recommends that the sequence of Knowledge areas in each grade should be:

1. Life at molecular, cellular and tissue level
2. Life processes in plants and animals
3. Environmental studies
4. Diversity, change and continuity

The rationale for the order is the same as that for the NCS 2, which is that practical work related to the environment should take place in early spring, which is the third term. However, teachers are given the option to teach environmental studies in the first term. Teachers are advised to retain the sequence of Knowledge area 1 before Knowledge area 2, and Knowledge area 3 before Knowledge area 4. Teachers are explicitly allowed the freedom to decide whether to begin with Knowledge areas 1 and 2, or to start with Knowledge areas 3 and 4 (Doc 2.1, p 11).

Although statements about freedom to choose the broad sequence are made in the preliminary pages of both curricula, the linear sequencing of content in both documents is easily interpreted to be prescriptive. The CAPS supports this impression by allocating topics to terms, e.g. Grade 10 Term 1 *'Life at the molecular, cellular and tissue level'* (Doc 2.1, p 23). Teacher initiative is repeated in the following statement: *'... educators have the freedom to expand concepts and to design and organise learning experiences according to their local circumstances, including the availability of resources'* (Doc 2.1, p 10). This statement is repeated almost verbatim from the NCS 2 (Doc 1.5, pp 5 - 6). However, prescribed assessment tasks, set at district and provincial level, restrict the amount of freedom a teacher has in practice to deviate from the sequence given in Doc 2.1.

One advantage of all schools following the same sequence of content is to accommodate learners moving from school to school. Members of the evaluation team cited problems when learners relocate to another school or province. The sequence in which content is taught has previously mirrored the sequence of the two examination papers at the end of the year. If a school deviated from the recommended content sequence, it created problems when learners moved schools. This will change when the CAPS is implemented, since both examination papers in the CAPS examine topics taught over the whole year in Grade 12.

The four Knowledge areas of the NCS 1 and NCS 2 are retained as curriculum organisers in the CAPS, but do not all appear in each year. 'Photosynthesis' and 'Cellular respiration', which are conceptually part of Cellular and molecular biology, are placed in the strand 'Life processes in plants and animals' (Doc 2.1, pp 42, 45), and Plant reproduction is placed in the strand 'Diversity, change and continuity' rather than its logical home, which is 'Life processes'. The Knowledge areas as curriculum organisers have outlived their usefulness and should be abandoned in future curriculum revisions.

### 2.8.2 Indication of progression

Progression is the increase in the level of complexity or difficulty at which a topic is addressed through a grade or phase.

The ideal sequence of topics within a biology/life sciences curriculum is a matter for debate. The discipline of biology as a whole can be argued to be fairly hierarchical (Bernstein, 1999), in that the theory of evolution serves as a general organising concept which integrates knowledge at lower levels. In addition, several sub-disciplines within biology have hierarchical content material e.g. Anatomy (cells, tissues, organs, organ systems) and ecology (population, community, ecosystem, biome, biosphere). Classification is also intrinsically hierarchical. But all these sub-disciplines could be studied either 'from the bottom up', or 'from the top down'. In a school curriculum, it could also be argued that as the ability to think in the abstract may not yet be fully developed, even in a child at FET level (Osborne, 1996), it is better to leave more abstract concepts until later, and teach more concrete concepts earlier.

Nevertheless, according to Schmidt *et al*'s (2005) criteria for curriculum coherence, it is important that foundational knowledge be laid down first. Thus, understanding meiosis is foundational to understanding life cycles in plants, and a knowledge of cell structure underpins an understanding of tissues.

General Biology textbooks usually begin with '*Biochemistry*', followed by '*Cells*', '*Whole organisms*' and finally '*Ecosystems*. '*Diversity and evolution*' usually occupy a place in the middle of the textbook. This organisation parallels the levels of organisation of life, but Campbell and Reece (2005) in the preface to their comprehensive introductory biology textbook, state the following: *'... we realize that there is no one 'correct' sequence of topics for a general biology course. Though a biology textbook's table of contents must be linear, biology itself is more like a web of related concepts without a fixed starting point or a prescribed path'* (Campbell & Reece, 2005, p ix).

Campbell and Reece (2005) suggest that biology courses could just as easily start with '*molecules, with evolution and the diversity of organisms, or with the big-picture ideas of ecology*' (Campbell and Reece, p ix).

The concept map shown in NCS 2 (Doc 1.5, p 5) captures the notion of biology as a web of related concepts, with two focus points: The whole '*Living organism*', and '*Evolution by natural selection*'. The map is drawn without a starting point or an ending point. It is repeated here for reference purposes.

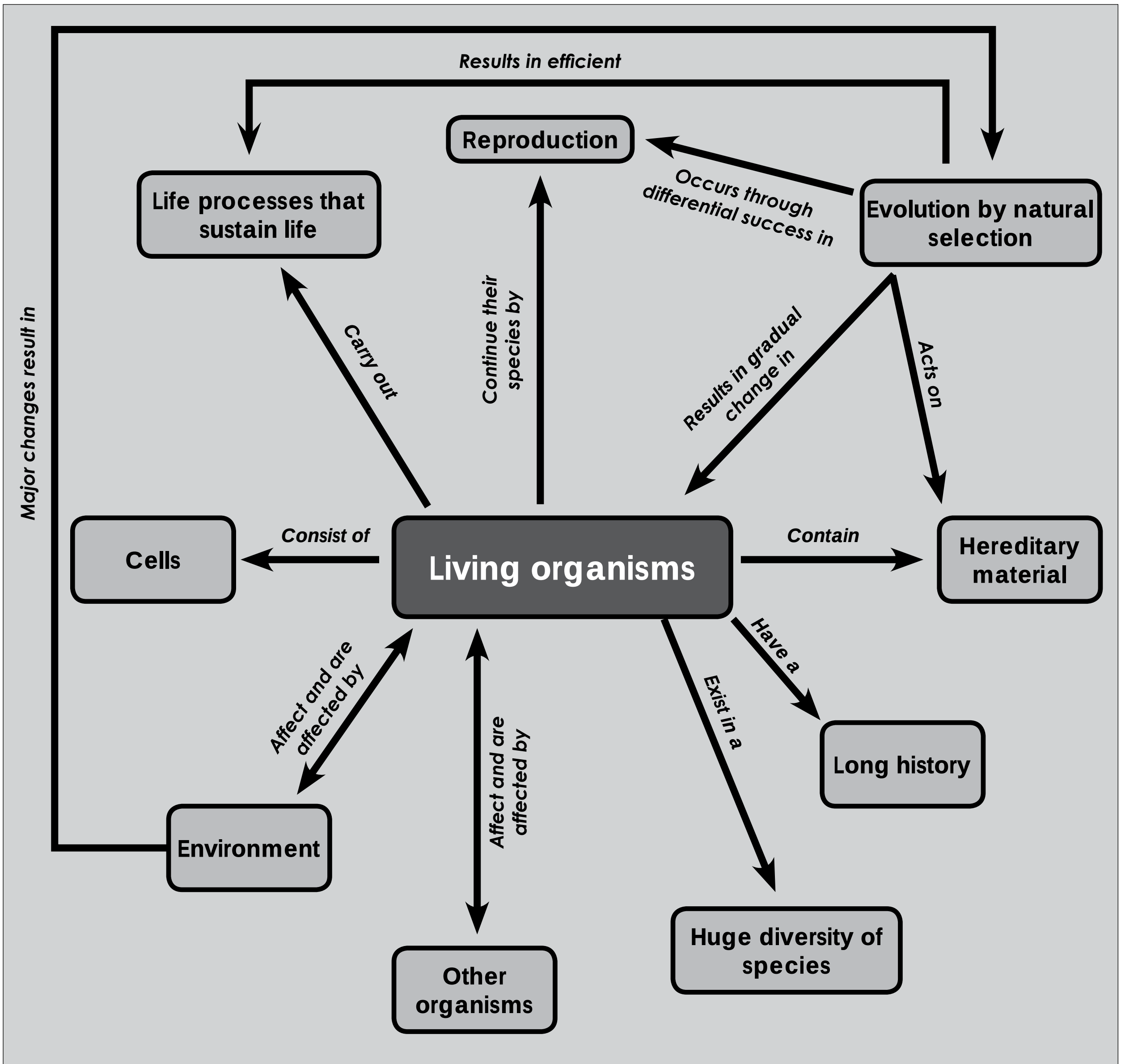


**Figure 6: An overview of the holistic nature of Life Sciences**

A further consideration in sequencing topics in biology is the movement from concrete to abstract. Concrete is that which can be observed without the need for scientific instruments, e.g. A whole organism is concrete, while cells and molecules are more abstract. Osborne (1996) constructed three realms of scientific theory, which could be used to sequence a science curriculum. Realm 1 theory relates to objects and phenomena that can be perceived by the human senses. In biology, this could be macro-organisms and life processes familiar to learners. Realm 2 theory relates to objects and phenomena that can only be seen with the aid of technical instruments. Examples in biology are tissues, cells and cell organelles, and micro-organisms. Realm 3 theories relate to theoretical objects and phenomena that are described on the basis of indirect evidence, such as the structure of molecules, biochemical processes and mathematical models. Although Osborne (1996) argues for a science curriculum to begin with Realm 1 knowledge, followed by Realm 2, and finally Realm 3, he also recognised that a flexible approach is necessary, responsive to the context and learning styles of different groups of learners.

A curriculum that starts with molecular and cellular biology may be starting at the lowest level of organization of life, but it is Realm 2 knowledge rather than Realm 1 knowledge (Osborne, 1996). It is possible, and may be advisable, to start with that which is concrete, e.g. '*The diversity of life*', or '*Ecosystems*', which are visible and familiar to learners, and progress to structures that can only be seen with the use of scientific instruments, e.g. '*Cells*', and later structures that can only be modelled, e.g. '*Molecules*'.

**Table 15: Indication of progression: Within and across grades**

| | | NCS | CAPS |
|---|---|---|---|
| Within grades | **Level of indication** | Moderate | Moderate |
| | **Rationale/justification** | Sequence of topics is recommended, but not prescribed. | Sequence is recommended and implied by the linear organisation of the content by grade. |
| Across grades | **Level of indication** | Strong | Strong |
| | **Rationale/justification** | Depth increases from Grade 10 to Grade12. Knowledge areas are revisited in each grade. | Depth increases from Grade 10 to Grade 12. Knowledge areas are not all re-visited in each Grade. |

### Progression in depth and breadth across grades

A summary of progression in breadth and depth across the generic content areas is shown in Table 16.

| **Table 16: Average depth and breadth of generic topics per grade (number of sub-topics, in parentheses)*** | | | | | | |
|---|---|---|---|---|---|---|
| **Generic topic** | **NCS 2** | | | **CAPS** | | |
| | **Gr 10** | **Gr 11** | **Gr 12** | **Gr 10** | **Gr 11** | **Gr 12** |
| Nature and history of science | 4 (1) | 4 (1) | 4 (1) | 3 (1) | 0 | 4 (1) |
| Molecular and cellular biology | 1,8 (5) | 0 | 0 | 2,3 (3) | 2,5 (2) | 0 |
| Genetics and heredity | 1,5 (2) | 0 | 2,6 (5) | 1,3 (3) | 0 | 2,2 (5) |
| Evolution & Diversity | 2,0 (3) | 2,4 (5) | 3,0 (3) | 3,0 (2) | 2,0 (3) | 3,3 (3) |
| Ecology | 2,0 (3) | 2,0 (2) | 2.7 (3) | 2,0 (3) | 3,3 (3) | 0 |
| Life processes in animals | 2,5 (6) | 2,4 (7) | 2,6 (5) | 2,5 (4) | 2,5 (6) | 2,2 (5) |
| Life processes in plants | 2,0 (1) | 1,7 (3) | 2,7 (3) | 2,0 (2) | 1,5 (2) | 1,5 (2) |
| Indigenous knowledge | 1 (1) | 1 (1) | 0 | 1 (1) | 1 (1) | 0 |
| Relationship to work | 1 (1) | 1 (1) | 0 | 1 (1) | 0 | 0 |
| Ethics, attitudes and values | 2 (1) | 3 (1) | 4 (1) | 2 (1) | 0 | 0 |
| Unclassified | 0 | 0 | 1 (1) | 0 | 1 (1) | 0 |
| **Total** | **2,0 (24)** | **2,2 (21)** | **2,7 (22)** | **2,1 (21)** | **2,3 (18)** | **2,4 (16)** |

* Calculation of depth and breadth is described under 2.5.1

In the NCS 2, all four knowledge areas are re-visited in each year of study, providing continuity in the knowledge areas. The CAPS also exhibits continuity in the four knowledge areas, although cell biology is omitted in Grade 11, and Environmental studies in Grade 12. Table 16 shows that in both curricula there is an overall increase in depth over the grades, and decreasing breadth between Grades 10 and 12.

Table 16 shows that depth does not progress uniformly over all generic topics in each grade. The topic '*Evolution and Diversity*' in the NCS 2 illustrates the progression one would expect if topics were followed through at increasing depth from grade to grade. However, for most topics in Life Sciences, major themes are represented in each year of study, but the actual topics covered varies. '*Life processes in animals*' is a good example, where different life processes are studied in each year of study. As is the case in most senior secondary curricula, '*Coordination*' is the most complex life process, and is studied in the final year of the phase. '*Genetics and heredity*', together with '*DNA structure and function*', are also studied in the final year of the senior secondary phase, although related concepts may be introduced earlier.

Figures 1a and 1b in Annexure A are taken from Johnson *et al.* (2011) and Johnson et al. (in prep). They map the sequencing and progression in the NCS 2 and the CAPS respectively across grades according to the knowledge areas.

## Conceptual progression across grades

The recommended sequence of major topics per grade in the NCS 2 and the CAPS are shown in Table 17. The sequencing allowed the team to consider whether conceptual progression is evident across the grades.

**Table 17: Progression across grades within knowledge areas.**

| Knowledge Area | NCS 2 | | | CAPS | | |
|---|---|---|---|---|---|---|
| | Gr 10 | Gr 11 | Gr 12 | Gr 10 | Gr 11 | Gr 12 |
| Life at the molecular, cellular and tissue level | Molecules, cells, tissues and organs | Diversity of viruses, bacteria, protists and fungi | DNA structure and function, meiosis, genetics | Molecules to tissues | | DNA structure and function, meiosis and genetics |
| Life processes in plants and animals | Life processes that sustain life (photosynthesis, nutrition, cellular respiration and gaseous exchange) | Life processes related to homeostasis (support and transport in plants, supporting systems and movement in animals, transport in animals, excretion) | Responding to the environment and reproduction in plants and animals | Support and transport systems in plants and animals | Energy transformations to support life (photosynthesis, nutrition, cellular respiration, gaseous exchange, excretion) | Responding to the environment, homeostasis and animal reproduction |
| Diversity, change and continuity | History of life and biodiversity | Plant and animal diversity, descent with modification and biogeography | Evolution by natural selection, speciation and human evolution. | Biodiversity and classification; history of life | Biodiversity of microorganisms, plants and animals and reproduction in plants | Darwinism and natural selection; human evolution |
| Environmental Studies | Biospheres to ecosystems | Human influences on the environment | Population and community ecology | Biospheres to ecosystems | Population ecology and human impact on the environment | |

## Progression within knowledge areas across grades

Table 17 shows the progression across grades per knowledge area. In the Knowledge area **Life at the molecular, cellular and tissue level**, the sequence in the NCS 2 is '*Molecules*, tissue and organs' in Grade 10, followed by '*Micro-organisms and fungi*' in Grade 11, and then '*DNA structure and function*' and '*Genetics*' in Grade 12. The biochemical processes of '*Photosynthesis*' and '*Cellular respiration*' are included under '*Life processes*' in Grade 10. This is a relatively logical sequence, with Grade 10 work being foundational to Grade 11 and Grade 12 work. The '*Diversity of micro-organisms*' topic in Grade 11 could equally be placed in the '*Diversity*' strand, a change which was made in the CAPS. In the CAPS, Grade 10 and Grade 12 are unchanged from the NCS 2, but no content is allocated to this knowledge area in Grade 11. '*Photosynthesis*' and '*Cellular respiration*' is retained under '*Life processes*' in the CAPS Grade 11, providing conceptual continuity, although the topics are mis-allocated to knowledge areas. The re-organisation that has been implemented in the CAPS has partially improved conceptual progression, but '*Photosynthesis*' and '*Cellular respiration*' should be placed in this knowledge area to provide progression from molecular structures in Grade 10 to processes in Grades 11 and 12.

Within the knowledge area, **Life processes in plants and animals**, the sequence in NCS 2 is '*Photosynthesis*', '*Animal nutrition*', '*Cellular respiration*' and '*Gaseous exchange*' in Grade 10, followed in Grade 11 by '*Support and transport in plants*'; '*Support, movement, and transport in animals*' and '*Human excretion*', and finally '*Animal and plant reproduction*', '*Plant and animal responses to the environment*' in Grade 12. The sequence from Grade 10 to 11 is not appropriate, since it introduces '*Digestion and gaseous exchange*' before the '*Circulatory system*' has been taught. The sequence has been reversed in the CAPS, with the exception of '*Excretion*', which remains in Grade 11. The Grade 12 curriculum is the same in both curricula, apart from '*Reproduction in plants*', which has been moved to the knowledge area, '*Diversity, change and continuity*', in Grade 11 in the CAPS. The CAPS sequence shows better conceptual progression than the NCS 2 in this knowledge area.

Within the knowledge area **Diversity, change and continuity**, the sequence in the NCS 2 is '*Biodiversity*' and '*Classification and history of life*' in Grade 10, '*Plant and animal diversity*', '*Descent with modification and biogeography*' in Grade 11, followed by '*Evolution by natural selection*', and '*Human evolution*', '*Evolution in present times*' in Grade 12. This sequence shows conceptual progression (Johnson et al., 2011). In the CAPS, Grade 10 is unchanged, except for the inclusion of '*Biogeography*'. Grade 11 includes the '*Biodiversity of microorganisms*', '*Diversity of plants and animals*', and '*Plant reproduction*', but not '*Descent with modification*'. Grade 12 in the CAPS is the same as the NCS 2. There is a gap in the conceptual progression in this knowledge area in the CAPS, due to the exclusion of descent with modification in the CAPS Grade 11.

Within the knowledge area, **Environmental studies**, the sequence in the NCS 2 is '*Biospheres*' to '*Ecosystems in Grade 10*', '*Human impact on the environment*' in Grade 11, and '*Population*', '*Community ecology*' and '*Succession*' in Grade 12. The conceptual progression is interrupted by the insertion of an applied topic in the middle. Grade 10 is unchanged in the CAPS, but all the topics from Grades 11 and 12 in the NCS 2 are taught in Grade 11 in the CAPS. '*Community ecology*' is reduced and incorporated into '*Population ecology*', which is conceptually incorrect. No topics in this knowledge area are taught in Grade 12, but the topic '*Human impact on the environment*' is examined in the preliminary and final Grade 12 examinations. The implication is that the teaching year in Grade 12 is contracted to the period before the preliminary examinations.

Conceptual progression across the grades is improved in the CAPS in two knowledge areas, and reduced in two. In particular, the foundations on which the theory of evolution are based (the '*Fossil record*' and '*Descent with modification*') have been weakened through the omission of '*Comparative anatomy*' and the evidence for '*Descent with modification*'.

### Conceptual progression within grades

Although both documents allow for teachers to choose a sequence within each grade, the linear organisation of the curriculum implies a particular sequence. The sequencing as recommended in the NCS 2 and the CAPS is shown in Tables 18, 19 and 20.

| Table 18: Recommended sequence of topics in Gr 10 NCS 2 and CAPS | | | |
|---|---|---|---|
| **Knowledge Area** | **NCS 2, Gr 10** | **Knowledge area** | **CAPS, Gr10** |
| **Environmental studies** | 1. Biosphere<br>2. Biomes<br>3. Ecosystems | **Life at molecular, cellular and tissue level** | 1. Molecules for life<br>2. Cell structure and function<br>3. Mitosis<br>4. Plant and animal tissues<br>5. Organs |
| **Diversity, change and continuity** | 4. Biodiversity and classification (kingdoms)<br>5. History of life on earth | **Life processes in plants and animals** | 6. Anatomy of dicotyledonous plants<br>7. Transpiration<br>8. Types of skeletons<br>9. Human musculoskeletal system<br>10. Human circulatory system |
| **Life at molecular, cellular and tissue level** | 6. Molecules for life<br>7. Cell structure and function<br>8. Mitosis<br>9. Plant and animal tissues<br>10. Organs | **Environmental studies** | 11. Biosphere<br>12. Biomes<br>13. Ecosystems |
| **Life processes in plants and animals** | 11. Photosynthesis<br>12. Respiration<br>13. Animal nutrition<br>14. Gaseous exchange | **Diversity, change and continuity** | 14. Biodiversity and classification (kingdoms)<br>15. Life's history |

The levels of organisation of life are evident in the sequencing, but the NCS 2 begins at the macro-level with '*Biomes and ecosystems*', progressing to '*Diversity*' and '*Classification*' (including fossils), before going to the micro-level of '*Molecules, cells and tissues*', followed by '*Life processes in plants and animals*'. This fits with Osborne's proposal of starting with Realm 1 knowledge (biomes, ecosystems and diversity) before Realm 2 (tissues, cells and molecules). The life processes chosen for Grade 10 ('*Photosynthesis*' and '*Cellular respiration*') progress from the structure of molecules to biochemical processes, and these two life processes are coherent with the organ-system functions of digestion and gaseous exchange. Knowledge of different tissues is foundational to understanding the structure and functioning of the digestive system and the respiratory system.

The CAPS elects to begin at the micro-level with '*Molecular and cellular biology*', progressing to the '*Structure of whole plants*', the '*Structures providing support in plants and animals*', allowing for movement and the transport of substances in whole organisms. Research on children's ideas of what is inside their bodies shows that at Grade 9 level, children are most aware of their musculoskeletal and digestive systems, followed by the respiratory system (Dempster & Stears, 2013). Starting with the '*Musculoskeletal system*' recognises the sequence in which learners identify their internal anatomy. Coherence is created by linking '*Transport and support*' in plants and in animals.

The CAPS then moves to the macro-level by progressing to the '*Biosphere, biomes and ecosystems*'. This is followed by an introduction to the '*Diversity of life*' and its division into kingdoms, and the '*History of life*' as recorded in fossils. Knowledge of '*Cell structure*' is required to understand the division of life into prokaryotes and eukaryotes cells, which is an important distinction in '*Biodiversity*'.

The CAPS therefore begins with Realm 2 concepts and moves to Realm 1. In both curricula, there is strong coherence between the Molecular/cellular biology and the Life processes knowledge areas, but less coherence between the Environmental studies and Diversity knowledge areas. It would be conceptually more coherent for learners to study '*Biodiversity*' before the higher ecological levels. The order recommended by the NCS 2 deals with Realm 1 concepts before Realm 2, but has the disadvantage that learners have not yet encountered the structure of cells, and therefore the prokaryote/eukaryote distinction is difficult to introduce.

**Table 19: Sequence of topics in Gr 11 NCS 2 and the CAPS**

| Knowledge Area | NCS 2, Gr 10 | Knowledge area | CAPS, Gr10 |
|---|---|---|---|
| **Life processes in plants and animals** | 1. Anatomy of dicotyledonous plants<br>2. Transport in plants<br>3. Types of skeletons<br>4. Human musculoskeletal system<br>5. Human circulatory system<br>6. Excretion in humans | **Diversity, change and continuity** | 1. Viruses, bacteria, protists and fungi<br>2. Immunity<br>3. Plant diversity (division level)<br>4. Asexual and sexual reproduction<br>5. Flowers as reproductive structures<br>6. Significance of seeds<br>7. Animal diversity (phylum level) |
| **Life at molecular, cellular and tissue level** | 7. Viruses, bacteria, protists and fungi<br>8. Immunity | **Life processes in plants and animals** | 8. Photosynthesis<br>9. Human nutrition<br>10. Cellular respiration<br>11. Gaseous exchange<br>12. Excretion in humans |
| **Diversity, change and continuity** | 9. Plant diversity (division level)<br>10. Animal diversity (phylum level)<br>11. Modifications of basic body plans<br>12. Biogeography | **Environmental studies** | 13. Population size<br>14. Interactions in the environment<br>15. Social organisation<br>16. Ecological succession<br>17. Human population<br>18. Human impact on the environment |
| **Environmental studies** | 13. Human influences on the environment | | |

The **NCS 2** begins with '*Support and transport systems*' in plants and animals, including the '*Musculoskeletal, circulatory and excretory systems*' in humans, and '*Transpiration*' in plants. It proceeds to '*Diversity of life*', covering a selection of six phyla of animals, and four divisions of plants, as well as viruses, bacteria, protists and fungi and their roles in the environment. This content is linked with '*Diseases and the immune response*'. '*Plant and animal diversity*' is taught from a historical perspective, with an attempt to identify changes over time in key features of selected divisions of plants and animal phyla. The principle of '*Descent with modification*' is introduced, and reinforced through comparative anatomy examples such as the vertebrate forelimb. '*Biogeography*', which is a foundation concept in the development of the concept of evolution, follows '*Comparative anatomy*'. Grade 11 ends with a section on '*Human impact on the environment*', dealing with topical issues related to the environment.

The **NCS 2** for Grade 11 moves between Realms 1 and 2 knowledge, but its major theme is '*Diversity and classification*', which is linked to '*Descent with modification*'. A second focus is '*Structure-function relationships*' as evidenced in the Life processes knowledge area. The human influence is related in some respects to the '*Diversity*' theme, since humans generally reduce biodiversity.

The **CAPS** for Grade 11 begins with '*Diversity*' of all the kingdoms, but introduces '*Plant reproduction*' between '*Plant diversity*' and '*Animal diversity*'. '*Animal reproduction*' is taught in Grade 12, and the subject advisors on the team report that '*Plant reproduction*' was moved to Grade 11 because Grade 12 was overcrowded. However, it interrupts the development of an understanding of diversity and classification in the CAPS.

Thereafter, the life processes of '*Photosynthesis*', '*Digestion*', '*Cellular respiration*', '*Gaseous exchange*' and '*Excretion*' follow. There is no obvious connection between the life processes knowledge area and the diversity knowledge area. After the life processes, '*Ecological processes*' at population and community level are taught. The year ends with '*Human impact on the environment*'.

It is difficult to identify progression within Grade 11, either in the NCS 2 or in the CAPS. The concepts move between Realm 1 and Realm 2, with Realm 3 being introduced in some of the population ecology models.

**Table 20: Sequence of topics in Gr 12 NCS 2 Examination Guidelines and the CAPS**

| Knowledge Area | NCS 2, Gr 10 | Knowledge area | CAPS, Gr10 |
|---|---|---|---|
| **Life at molecular, cellular and tissue level** | 1. DNA and RNA structure and function<br>2. Meiosis<br>3. Genetics and genetic engineering | **Life at molecular, cellular and tissue level** | 1. DNA and RNA structure and function<br>2. Meiosis<br><br>5. Genetics and inheritance |
| **Diversity, change and continuity** | 4. Evidence for evolution<br>5. Evolution by natural selection<br>6. Speciation<br>7. Mechanisms for reproductive isolation<br>8. Human evolution<br>9. Evolution in present times<br>10. Alternative explanations | **Life processes in plants and animals** | 3. Diversity of reproductive strategies in some animals<br>4. Human reproduction<br><br>6. Human nervous system<br>7. Human endocrine system<br>8. Homeostasis<br>9. Plant responses to the environment |

| Table 20: Sequence of topics in Gr 12 NCS 2 Examination Guidelines and the CAPS (continued) | | | |
|---|---|---|---|
| **Knowledge Area** | **NCS 2, Gr 10** | **Knowledge area** | **CAPS, Gr10** |
| **Environmental studies** | 11. Intraspecific competition<br>12. Population size<br>13. Social organisation<br>14. Community structure<br>15. Ecological succession | | |
| **Life processes in plants and animals** | 16. Plant responses to the environment<br>17. Human nervous system<br>18. Human endocrine system<br>19. Homeostasis<br>20. Asexual and sexual reproduction<br>21. Life cycles<br>22. Flowers as reproductive structures<br>23. Diversity of reproductive strategies in some animals<br>24. Human reproduction | **Diversity, change and continuity** | 10. Evidence for evolution<br>11. Evolution by natural selection<br>12. Speciation<br>13. Mechanisms for reproductive isolation<br>14. Evolution in present times<br>15. Human evolution<br>16. Alternative explanations |

Table 20 shows that the Grade 12 year of the **NCS 2** starts at the molecular level with '*DNA structure and function*', followed by '*Genetics*'. It proceeds from '*Genetics*' to '*Evolution by natural selection*'. This sequence is contrary to that recommended in the NCS 2 (Doc 1.5), which placed '*Evolution*' at the end of Grade 12, drawing together all the concepts established previously.

The environmental studies knowledge area follows '*Evolution*', and deals with the ecological levels of population and community. '*Environmental studies*' is followed by a study of the life processes '*Reproduction*' and '*Responding to the environment*' in plants and animals. '*Reproduction*' should logically precede '*Genetics*'.

The Grade 12 year therefore moves between Realms, with a considerable emphasis on Realm 3 knowledge ('*Models of DNA, RNA, protein synthesis, genes*') and the abstract concepts of '*Evolution*'. Some aspects of '*Population*' and '*Community ecology*' are abstract (Realm 3) and others observable (Realm 1). The Life processes of '*Reproduction*' and '*Responding to the environment*' can be directly observed (Realm 1), although transmission of nerve impulses requires specialised equipment (Realm 2). There is no obvious progression over the year.

The **CAPS** Grade 12 year begins as the NCS 2 year does, with '*DNA structure and function*', but it then proceeds to '*Animal reproduction*' before '*Genetics*'. This is more coherent than is the case with the NCS 2. The life process '*Responding to the environment*' in plants and animals follows '*Genetics*'. This sequence is random. The year ends with '*Evolution by natural selection*', which is coherent with '*Genetics*' and '*Reproduction*', but not with '*Responding to the environment*'.

The CAPS Grade 12 has better structure and coherence overall than the NCS 2 Grade 12, as arranged in the Examination Guidelines (Doc 1.7).

Neither curriculum conforms to a Realm 1 to Realm 3 sequence, nor do they follow a sequence that starts at one end of the levels of organisation of life and progresses either up or down the levels. The two curricula illustrate that Biology is more like a web of related concepts than a strictly ordered sequence. However, the introduction of the four knowledge areas in the NCS 1 and the persistence of those knowledge areas through successive curriculum reforms intrudes on progression and coherence within years. The CAPS has begun to depart from strict adherence to the four knowledge areas revisited every year, and it is to be hoped that the trend will continue.

## 2.9 SPECIFICATION OF PEDAGOGIC APPROACHES

The pedagogic approach is the way in which teaching and learning is intended to happen in the classroom. It is often described as 'teacher-centred' or 'learner-centred'. A pedagogic approach can include more specific approaches such as problem-based learning, constructivist learning, direct instruction, etc.

Descriptors[10] were used to code the pedagogic approach specified in the curricula for Life Sciences (see Table 21).

**Table 21: Specified pedagogic approach**

| | NCS 2 | CAPS |
|---|---|---|
| **Subject-specific pedagogic approach** | Learner-centred | None |
| **Level of indication** | Low | Low |

### Description of subject-specific pedagogic approaches

***NCS***

OBE encourages a learner-centred and activity-based approach to education with the teacher in the background as the facilitator (Doc 1.1, p 2). The ASs are seen as vehicles of knowledge, skills and values through which the LOs can be achieved. (Doc 1.1, p 14). The content serves the LOs and is not the end in itself (Doc 1.1, p 32). Emphasis is placed on creating opportunities for all learners to realise their full potential as thinking and doing beings who contribute to an improved quality of life for themselves and others in society

9 **High:** High specification - detailed guidance is given in the curriculum regarding the preferred subject-specific pedagogic approach
**Moderate:** Moderate specification - some guidance is given in the curriculum regarding the preferred subject-specific pedagogic approach
**Low:** Low specification - the preferred subject-specific pedagogic approach is mentioned in a few places but no details are provided
**None:** No specification - the curriculum provides no information or guidance regarding the subject-specific pedagogic approach

(Doc 1.2, p 8). The approach to teaching and learning is by emphasising learning through experience and/or simulations (Doc 1.2, p 11). The NCS 2 specifically does not prescribe particular instructional strategies, but gives educators the freedom to expand concepts and to design and organise learning experiences according to their local circumstances (Doc 1.5, pp 5-6). Teachers are seen as mediators of learning, interpreters and designers of learning programmes and materials, leaders, administrators and managers, scholars, researchers and life-long learners, community members, citizens and pastors, assessors and subject specialist (Doc 1.1, p 5).

### *CAPS*

The CAPS promotes knowledge in local contexts, while being sensitive to global imperatives (Doc 2.1, p 4). *'Sensitive to global imperatives'* in terms of a Life Sciences curriculum implies promoting awareness of dilemmas facing humankind generally such as diseases and environmental issues, and research into ways of dealing with these. The CAPS achieves this by dealing with topics such as cancer (Doc 2.1, p 26); medical biotechnology, stem cell research (Doc 2.1, p 28); heart disease (Doc 2.1, p 32) and the extensive section on human impact on the environment in Grade 11 (Doc 2.1, p 51onwards). The local context is addressed through an ecological study in a local biome (Doc 2.1, p 33), and practical observation of ONE example of human influence on the environment in the local area (Doc 2.1, p 51).

The content framework does not prescribe particular instructional strategies or methodologies (Doc 2.1, p 10). Educators have the freedom to expand concepts and to design and organise learning experiences according to their local circumstances (Doc 2.1, p 10), as was the case with the NCS 2.

## Extent of guidance provided

### *NCS*

Guidance is given on how to design a learning programme (Doc 1.2, pp 12 -18). Guidance is given on how to execute investigations (LO1) and applications (LO3) (Doc 1.5, pp 10-35). Links to topics studied in other grades are indicated in the content (Doc 1.5, pp 10-35).

### *CAPS*

Very little direct guidance is provided with regard to a recommended pedagogy. A few 'teaching tips' are located, for example, where there are links in the content to previous grades, these are provided for the teacher to revise these (Doc 2.1, p 25). With regard to practical work, essential and optional experiments are indicated to the teacher (Doc 2.1, p 23). Guidance on how to present some content is also provided to the teacher, for example *'focus on the developmental lines and phylogenetic trees. No further details are required regarding the morphology of the six phyla'* (Doc 2.1, p 41). The verbs used do not always clearly specify who the instruction is intended for – the learner or the teacher, e.g. '*construct a timeline showing the history of life on earth*' (Doc 2.1, p 36).

## Appropriateness of approaches for learners

### *NCS*

Although the pedagogic approach encourages learners to develop inquiring and problem solving skills which support the practical application of knowledge (Doc 1.2, p 8), the learners with good solid parental support are likely to excel and the learners without the necessary support may struggle. In the NCS 2, the emphasis was on individual learning at the individual tempo of the learner and this was supported by a large number of tasks the learner had to perform: Well-resourced learners performed far better than learners with no support at home.

### *CAPS*

Learners are expected to work effectively as individuals and with others as members of a team (Doc 2.1, p 5). This approach accommodates different learning styles. The CAPS does not present an overtly constructivist approach to teaching and learning. A constructivist pedagogy is learner-centred, with an emphasis on group-work. This approach predominated in the initial period post-1994 but was shown to be problematic [see, for example Allais, 2007]. Osborne (1996) refers to studies on different learning styles which show that the group-work/constructivist approach suits only one of four types of learners. He proposes that science education requires a variety of teaching methods. Managing constructivist teaching and learning successfully requires a highly skilled teaching corps, which South Africa lacks at present (Osborne, 1996). The CAPS tends towards a transmission pedagogy, which may be a more suitable approach in many parts of the South African context at present.

## Comparison of the role of the teacher

In the NCS the teacher is the facilitator (Doc 1.1, p 2) who organises learning experiences, while active learners construct knowledge. The CAPS is ambiguous with regard to the role of the teacher: It is a learner-centred curriculum, in that learners are responsible for their own learning, but the teacher controls the learning process. Through the syllabus-style curriculum, emphasis is placed on mastering content. The teacher is described as a designer and organiser of learning (p 21).

The change in teaching/learning approach is subtle, but evident in the change in the order of LOs: where knowledge acquisition was LO 2 in the NCS, it is SA 1 in the CAPS. LO 2 uses the verbs *construct*, *acquire*, *understand*, and *apply* in relation to Life Sciences knowledge. SA 2 omits the verb construct from its explanation of SA 1, using the following key verbs in relation to Life Sciences knowledge: *acquire*, *understand and make connections*, *apply*, *analyse*, *evaluate* and *synthesize*. The verbs are clearly derived from Bloom's taxonomy, but it is notable that *construct* is omitted.

## 2.10 ASSESSMENT GUIDANCE

Assessment guidance was judged as general, subject-specific, both or neither, using a set of descriptors[11].

The degree of clarity of guidance regarding assessment was judged using another set of codes[12].

| **Table 22: Assessment** | | |
|---|---|---|
| | **NCS 2** | **CAPS** |
| **Number of assessment tasks specified** | **Gr 10 and Gr 11:**<br>7 tasks<br>**Gr 12:**<br>8 tasks | **Gr 10, Gr 11 and Gr 12:**<br>10 tasks |
| **Types of assessment specified** | **Gr 10 and 11:**<br>2 practicals<br>1 research project<br>2 controlled tests<br>1 mid - year examination<br>1 end-of-year examination: 2 theory papers<br>**Gr 12:**<br>2 practicals<br>1 assignment<br>2 controlled tests<br>1 mid-year examination<br>1 trial examination<br>1 end – of - year examination | **Gr 10 and 11:**<br>4 class tests<br>3 practicals<br>1 project/assignment<br>1 mid - year examination<br>1 end-of year examination: 2 theory papers and 1 practical exam<br>**Gr 12:**<br>3 tests<br>3 practicals<br>1 mid-year examination<br>1 project / assignment<br>1 trial examination (2 papers)<br>1 end - of - year examination (2 papers) |

11 **General:** General, generic assessment guidance is given
**Subject-specific:** Subject-specific assessment guidelines are provided
**Both:** Both general and subject-specific guidelines are provided
**Neither:** No assessment guidance is provided

12 **High:** Assessment information is detailed, specific, clear, and comprehensive, and is not likely to result in differing interpretations
**Moderate:** There is a moderate degree of information regarding assessment that is generally clear
**Low:** There are broad statements about assessment that lack clarity and allow for multiple interpretations
**None:** No guidance on assessment is provided

| Table 22: Assessment (continued) | | |
|---|---|---|
| | **NCS 2** | **CAPS** |
| **Examples of dominant types of assessment specified** | **Gr 10 and 11:** Practicals, tests and examinations are equally dominant<br>**Gr 12 :** Examinations | **Gr 10 and 11:** Class tests<br>**Gr 12:** Tests, practicals, examinations are equally dominant |
| **Specificity of assessment guidance** | Subject-specific | Subject-specific |
| **Clarity of assessment guidance (High/Moderate/Low)** | High | High |

### Similarities and differences in assessment guidelines across the curricula.

Assessment guidance in terms of types of assessments for Grades 10 and 11 is specified for the NCS in Doc 1.3, p 8 and for the CAPS in Doc 2.1, pp 68 - 69. A significant innovation in the CAPS exams is the inclusion of a practical exam in Grades 10 and 11 as part of the end-of-year examination. One team member commented as follows: *'On paper this is a wonderful and idealistic dream but in reality it is a nightmare. Schools are responsible for setting this exam according to the resources available at school: In some schools, the practical exam is a full scale University-like practical exam; in some it is a pencil-and-paper exercise and in some a mixture'.*

The South African Institute for Race Relations reported in 2012 that only 15% of public schools have laboratories and 5% have equipment (SAIRR, 2012). Resources are allocated according to the quintile of the school. Thus Quintile 1 schools are those located in the poorest communities, and they receive more funding than a Quintile 5 school, located in a middle-class community. A Quintile 5 school that has attracted learners travelling from poor communities is disadvantaged because it does not qualify for resources.

Despite the reservations expressed by evaluation team members, there are many practical activities in Life Sciences that can be carried out without a laboratory, or with very simple equipment. For example, dissecting flowers can be achieved in a classroom; dissecting kidneys or hearts requires some sharp knives or scalpels. For Grade 12s, assessment guidance in terms of types of assessments is given in the NCS in Doc 1.3, p 11 and in the CAPS in Doc 2.1, p 70.

### School-Based Assessment

The number of tasks prescribed in the NCS 2 for Grades 10 and 11 has been increased from 7 to 10 in the CAPS. In Grade 12, the number of tasks has increased from 8 to 10. The types of assessment in all grades are the same in both curricula, comprising practicals, tests, project/assignments and formal exams. In the NCS 2, a project is done in Grades 10 and 11 and an assignment is done in Grade 12. In the CAPS, there is a choice between an assignment and project in all grades. The weighting of the School Based Assessment (SBA) mark to the end-of-year examination mark is 25%:75% in both curricula and in all grades, but the weighting of each component task in the SBA varies.

In the NCS 2 Grades 10 and 11, practical tasks contribute 50% to the SBA, the research project contributes 20%, controlled tests contribute 20% and the mid-year examination contributes 10% (Doc1.3, p 8).

In the CAPS Grades 10 and 11, the weighting of different tasks is variable. All the tasks completed in each term contribute 25% towards the SBA (Doc 2.1, p 70). However, the practical tasks can be between 20 to 40 marks and the test in each term has a minimum of 50 marks. The ratio of marks from practicals to tests can differ from school to school when schools set their own tasks and tests. The project/assignment has a mark of 100, which affects its weighting in the term in which it is completed. The number and types of tasks differ from term to term, which affects the weighting of different types of tasks, but overall, each term's composite mark contributes 25% to the final SBA mark.

In the NCS Grade 12, practical tasks contribute 40% to SBA, the assignment contributes 20%, controlled tests contribute 20% and the Mid-Year and Trial Exams both contribute 20% towards the SBA (Doc1.3, p 11).

In the CAPS Grade 12, the composite mark from practicals, tests and assignments completed in each term contributes 33.3% towards the SBA for the year (Doc 2.1, pp 68 - 69). Weighting of individual tasks within each term is variable.

### Summative examinations

The examination guidelines (Doc 1.7, p 2) and the assessment chapter in the CAPS (Doc 2.1, pp 71 - 73) provide a detailed weighting of different topics in each Paper, weighting of LOs, and weighting of cognitive levels. The format of the written examination papers is given. This is summarised in Table 23, and does not change over the three grades.

**Table 23: Weighting of examination papers: NCS 2 and CAPS**

| | Description | NCS 2 | CAPS |
|---|---|---|---|
| **Learning Outcome (LOs)/ Specific Aims (SAs)** | LO1 | 30% | Content, concepts and skills across all topics. Practical work must be assessed in the written exam. SAs are not weighted |
| | LO2 | 60% | |
| | LO3 | 10% | |
| **Time per paper** | | 2.5 h | 2.5 h |
| **Marks per paper** | | 150 | 150 |

| Table 23: Weighting of examination papers: NCS 2 and CAPS (continued) | | | |
|---|---|---|---|
| | **Description** | **NCS 2** | **CAPS** |
| **Format of the exam paper** | Section A: Short objective-type questions | 33% | 33% |
| | Section B: Variety of questions | 40% | 53% |
| | | | |
| | Section C: Data response and mini-essay | 27% | 13% |
| **Cognitive Level** | Knowledge | 30% | 40% |
| | Comprehension | 30% | 25% |
| | Application | 20% | 20% |
| | Analysis, synthesis and evaluation | 20% | 15% |

The CAPS has increased the weighting on recall of knowledge relative to the NCS 2, and decreased the weighting on understanding and higher order cognitive skills. Section C of the examination papers in CAPS omits the data response question and is an essay worth 20 marks. The CAPS does not allocate weighting to the SAs, as the NCS 2 does for the LOs. It also omits the format of the papers, which is given in Circular S2 of 2013.

| Table 23: Weighting of examination papers: NCS 2 and CAPS | | | | | |
|---|---|---|---|---|---|
| **NCS 2** | | | **CAPS** | | |
| | | **% of marks** | | | **% of marks** |
| **Paper 1** | Life at the molecular, cellular and tissue level | 60 | **Paper 1** | Meiosis | 7 |
| | Diversity, change and continuity | 40 | | Reproduction in vertebrates | 4 |
| **Paper 2** | Life processes in plants and animals | 60 | | Human reproduction | 21 |
| | Environmental studies | 40 | | Responding to the environment (humans) | 27 |
| | | | | Human endocrine system | 10 |
| | | | | Homeostasis in humans | 7 |
| | | | | Responding to the environment (plants) | 7 |
| | | | | Human impact on the environment | 17 |
| | | | **Paper 2** | DNA | 19 |
| | | | | Meiosis | 7 |
| | | | | Genetics and inheritance | 30 |
| | | | | Evolution through natural selection | |
| | | | | Human evolution | 44 |

The NCS 2 provides weighting per knowledge area, while the CAPS provides a much more detailed weighting per topic, related to the number of weeks allocated for teaching a topic. In the CAPS Grade 10, Paper 1 examines topics taught in Terms 1 and 2, while Paper 2 examines topics taught in Terms 3 and 4 (Doc 2.1, p 71). In Grade 11, Paper 1 examines topics taught in Terms 2 and 3, and Paper 2 examines topics taught in Terms 1 and 2 (Doc 2.1, p 72). In Grade 12, each Paper examines topics taught throughout the year, i.e., from Terms 1 to 4. This is a departure from previous practice. '*Meiosis*' is examined in both Paper 1 and Paper 2 because it is linked to reproduction in Paper 1, and to genetics and evolution in Paper 2. It is therefore examined in both papers. '*Evolution by natural selection*' is merged with '*Human evolution*' and allocated 44% of the marks in Paper 2.

The assessment guidance is subject-specific and the clarity of the assessment is high in both curricula.

It is clear from discussions within the group that assessment dominates the approach to teaching and learning throughout Grades 10 to12. Thus members of the group expressed concern about the fact that the examination papers are not aligned with the terms in which topics are taught. One teacher commented as follows: *'Assessment is driving curriculum sequencing. That is a standardized way of making a decision on learner progress. It is problematic to teach content in a specific term, but examine it in another paper/ term. It causes problems for learners not having books or not attending class. They do not know at the end of the year what content fits in what paper, leading to not studying at all or studying the wrong content or trying to study all the content. It creates enormous problems for educators who did not or do not attend training. They are unaware of this and when they realize the muddling up of topics and papers, it is too late. It creates a lot of confusion. I decided to do content of paper 1 (Term 1 and 3) in front of the notebook and content for paper 2 (Term 2 and 4) at the back of the notebook.'*

A subject advisor commented that she has suggested to her teachers that they could use two notebooks, one for each paper, but taking into account ALL content is tested in both the March controlled test and June examinations. The hegemony of the final examinations over-rides the conceptual links within the subject. This surely begs a review of the artificial separation of the subject matter into two examination papers. In other countries, three papers are written on the whole phase, one consisting of multiple choice questions, a second being longer written questions, and the third paper being a practical examination (Dempster, 2012).

The DoE is driven by results, as the only measurable indicator of the functionality of the education system. Provinces are ranked according to their Grade12 results. Provinces that are ranked the lowest receive special attention in the next academic year. The political imperative to improve pass rates plays out in an unhealthy emphasis throughout the year on final assessment, which shapes the motivation used by teachers throughout the FET Phase. Schools that have low pass rates (underperforming schools) are targeted for special attention by the subject advisors who monitor and mentor teachers until the pass rate reaches an acceptable level. In most provinces, learners from underperforming schools attend special classes on Saturdays and during school holidays.

### General comments

A striking feature of the sequence of curricula from NCS 1 to NCS 2 to the CAPS is the progressive erosion of teacher autonomy and centralisation of control over assessment. Provinces vary in the amount of central control over SBA tasks. For example:

- In Gauteng, the tasks (except the tests and exams for Grades 10 and 11) are set by the provincial Life Sciences team, with the senior subject specialist leading the panel. Tests and exams are set by each region (a cluster of districts) in Gauteng. A choice of tasks is provided for Grades 10 to 12 in the NCS 2, but for the CAPS the tasks for Grades 10 to 12 are set centrally.
- In KwaZulu-Natal, control tests and exams are set and moderated centrally at provincial level for the under-performing schools for Grades 10-12 in the NCS and the CAPS. Many other schools use the centrally - set control tests and exams. Practicals, projects and assignments are not set centrally.
- In Western Cape, no common SBA tasks are set centrally. Teachers are expected to set their own assessment tasks.

The apparent freedom of choice that the official documents give to teachers about sequencing of content and timing of assessment tasks is eroded by the centralisation of assessment. Subject advisers justify central setting of assessment tasks because it addresses problems such as teachers pacing the work too slowly, unsuitable assessment tasks being set, or assessment tasks not conducted at all. One team member cited her personal experience as follows: *'When I moderated portfolios one year, some schools sent in assignments dated two years previously.'* Having one common task makes moderation by the teacher moderators considerably easier. There is only one memo, and the moderators know that the schools have done some form of assessment. Thus assessment provides a means of monitoring that teachers are carrying out prescribed tasks.

Common assessment tasks have the adverse effect of prioritising summative assessment over formative assessment, and learning is structured so that it is extrinsically motivated, rather than the ideal intrinsic motivation. Formative assessment is lacking in many South African schools, as attested by team members, and teachers only conduct the formal, prescribed assessment tasks. Practical work is not conducted as an essential component of learning Life Sciences.

Since the NCS was intended to be an outcomes-based curriculum, the measure of progress towards achieving the ASs, and thereby LOs, should be central to the assessment process. For the NCS 1 and the NCS 2, teachers were required to indicate the LOs on their portfolio assignments and tests/examinations for Grade 12, but not the ASs. As the CAPS is rolled out in Grades 10 and 11, the SAs are indicated on the formal assessment tasks, which are still prescribed and set by the district or the province, but there is no specified weighting of SAs in the CAPS as was the case for the LOs in the NCS 1 and NCS 2. This is further evidence that the CAPS has abandoned Outcomes-Based Education (OBE) as the approach for South African schools.

## 2.11 CURRICULUM INTEGRATION

### 2.11.1 Integration between subjects

Life Sciences is an elective subject that may be studied alongside a large range of different subjects. Integration of Life Sciences with other subjects is not expected, because learners may be studying a range of other electives.

Codes[13] were used in the analysis of integration between subjects.

| Table 25: Integration between subjects | | |
|---|---|---|
| | NCS | CAPS |
| **Level of integration (High/moderate/low)** | None | Low |
| **Example (only 1 example found)** | | Developing language skills: Reading and writing<br>(Doc 2.1, p 19) |

Integration between subjects and fields is mentioned in the Introduction part of the NCS Subject Statement document (Doc 1.1, p 3), but when content is elaborated, integration is not apparent.

Integration between subjects and phases is mentioned in the Orientation part of the CAPS (Doc 2.1, p 22), but does not emerge in the contents section. Integration with languages is mentioned in the CAPS (Doc 2.1, p 19) where it is intended that when teachers teach Life Sciences they have to develop and improve learners' language skills.

### 2.11.2 Integration with the everyday world and knowledge of learners

The level of integration between the formal subject knowledge in the curriculum and the everyday (general) knowledge of learners was assessed using codes[14].

| Table 26: Integration between subject and everyday knowledge | | |
|---|---|---|
| | NCS | CAPS |
| **Level of integration** | Moderate | Low |
| **Example 1** | Link nutrient cycle and forestry to current environmental issues<br>(Doc 1.5, p 10, Doc 1.5, p 23) | Integration with world of work: -<br>Ecotourism (Doc 2.1, p 34)<br>- Fossil tourism (Doc 2.1, p 37) |
| **Example 2** | Link environmental lobbying and the importance of evidence is discussed using the case study of St Lucia<br>(Doc 1.5, p 26) | |

13 **High:** Frequent and explicit references are made to integration with other subjects in the curriculum
**Moderate:** In a few places reference is made to other subjects or connection to topics in other subjects is made
**Low:** The subject is very separate from other subjects in the curriculum and there is very little or no referencing of other subjects

| Table 26: Integration between subject and everyday knowledge (continued) | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Example 3** | Integration with world of work:<br>• Fossil tourism as a source of income and employment (Doc 1.5, p 12)<br>• Careers in biotechnology(Doc 1.5, p 15)<br>• Ecotourism (Doc 1.5, p 26) | |

Integration with learners' everyday life and world of work is mentioned in a few places in both curricula but to a lesser extent in the CAPS. Examples are provided in Table 26. There are no explicit connections that are made to everyday knowledge and experience (Doc 1.5, p 26). Indigenous knowledge is identified in both curricula as important to acknowledge and incorporate into the subject, but the content provides very few opportunities to do so. An example is traditional technology, e.g. traditional processes for making beer, *mahewu*, *amasi* (Doc 1.5, p 22). In the CAPS the same statement is re-worded as *'Traditional technology to produce, e.g. beer, wine and cheese'* (Doc 2.1, p 39).

## 2.12 CURRICULUM OVERVIEW

### 2.12.1 Curriculum coherence

**Curriculum coherence** is the extent to which a curriculum reflects a logic (often inherent in the nature of the discipline itself) in the organisation of topics, where the key ideas of the subject and their development over time, is evident.

Both the NCS and the CAPS are coherent, in that they are both guided by a set of LOs (the NCS more so than the CAPS) and organised according to four knowledge areas. The knowledge areas are re-visited in each grade in the NCS, but omitted in two places in the CAPS. The NCS 2 curriculum is organised according to the three LOs, with each LO occupying a separate column in the content pages. The CAPS states the SAs, and uses two SAs (SA1 and SA2) to organise the curriculum. The columns are headed 'Content', which represents SA1and SA3, and 'Investigations' which represents SA2. SA3 is not distinguished from SA1 in the 'Content' or the 'Investigations' columns.

The NCS has a stated logic for its organisation.  In Doc 1.5, pp 4 - 7, Figure 1 under point 11.2 illustrates that biology is perceived as a web, with no fixed starting point and end point. The CAPS describes the four knowledge areas, provides a sequence and a justification for the choice of the sequence. However, it recognises that teachers may wish to deviate from the prescribed sequence (Doc 2.1, p 11).

A criticism of the coherence of the CAPS is that no weighting is given to the SAs in the assessment guidance. Thus, the SAs are stated and elaborated, but they are not the focus of the curriculum, as is the case for the outcomes-based NCS.

### 2.12.2 Implications for South African context

The NCS 2 was too ambitious, in that it attempted to include too much subject matter in each year's curriculum. LO 3 included a great deal of material that enhanced learners' understanding of the nature and history of science, ethics and attitudes in science, indigenous knowledge, and environmental issues arising in the South African context. However, teachers were not prepared for this curriculum, which was introduced three years after an earlier curriculum change.

The CAPS has reduced content, compared with the NCS 2, but has added more practical investigations, with a practical examination as a requirement in Grades 10 and 11. This brings its own challenges, which are described in Section 2.10.

In summary, the CAPS (Doc 2.1, p 19) anticipates that every learner should have access to sufficient workspace and equipment to carry out the prescribed investigations. For safety reasons, no more than three learners should share space and equipment if there is insufficient equipment for a large class. The CAPS acknowledges that it is not ideal to use improvised equipment, but it is more important for learners to have the experience of carrying out investigations than to depend on standard laboratory equipment being available. The reality of only 5% of South African schools having equipped laboratories means that the goal of the CAPS is remote.

### 2.12.3 Assumptions regarding teacher expertise

With regard to the NCS 2 and the CAPS, teachers were not equipped to teach the '*History of life*', '*Descent with modification*', '*Phylogenetic trees*', '*Evolution by natural selection*' and '*Human evolution*'. Even though '*Genetics*' has been included in the FET curriculum for many years, many teachers still lack confidence in teaching this topic. Despite the fact that all the topics related to '*Evolution*' were present in the NCS 1, teachers still refer to these as 'new topics', and report feeling under-prepared to teach those topics (Keke, 2013).

With regard to the CAPS, teachers do not appear to know how to incorporate the practical work into ordinary classwork, and how to structure a practical examination that is not a pencil-and-paper test. The lack of laboratories and equipment at most schools is also a limiting factor, but the greatest problem appears to be teachers' lack of confidence and willingness to incorporate practical work into their classes. Many teachers are not qualified to teach Life Sciences, and novice teachers, even though they are qualified to teach Life Sciences, lack confidence in performing practical work. The result is that teachers do not carry out the practical work requirements.

Teachers also lack the skills to set tests and examination papers using a weighting grid and may feel that it is just an extra administrative burden on them. The HOD is often a Physical Science or Mathematics teacher who is not able to assist the Life Sciences teachers or to moderate their assessment tasks. Many teachers still have a problem in offering NCS/CAPS: They tend to teach the subject at the same level of detail as they did for the NATED 550 curriculum, which explains why they struggle to finish the syllabus. The NATED 550 curriculum applied until 2006, when NCS 1 was introduced into Grade 10. The NCS vastly reduced the breadth and depth of the disciplinary knowledge relative to NATED (Johnson *et al.*, 2011). New terms also appeared in the syllabus, e.g. validity and reliability with the NCS 2 and hypothesizing in the NCS 1. This caused uncertainty for the teachers.

The lack of competence and confidence of teachers is a reason for the centralization of formal assessment tasks. Competent teachers may be reluctant to take on extra work to help schools where teachers are less competent, because it is not part of the job description, and they receive no payment for extra work.

## 2.13 CONCLUDING REMARKS

Concluding remarks are arranged so as to answer the research questions informing this study.

**a. The extent to which the NCS curricula were repackaged or rewritten in the formulation of the CAPS**

The current study shows that the teaching approach has changed from outcomes-based in the NCS to syllabus-based in the CAPS. The NCS 2 used the three LOs as curriculum organisers, but the CAPS uses 'Content' and 'Investigations' as curriculum organisers. Both documents assign content to four knowledge areas, which correspond to levels of organisation of life and the study of diversity. The NCS 2 includes each knowledge area in each year of study, while the CAPS does not.

The curriculum content has been mostly repackaged in the transition from the NCS 2 to the CAPS. It has been reduced in depth and breadth, and some content has been moved between grades. It has also been re-arranged so that the SAs are not clearly linked to content topics. This affects particularly SA3, which is not clearly evident in the '*Content*' column.

The CAPS has increased the number of practical investigations, particularly the open-ended investigations, compared with the NCS 2. Reasoning skills have also increased. These are welcome changes in the curriculum.

Assessment has been re-organised to include an assessed authentic practical task in each term and a practical exam in Grades 10 and 11 in the CAPS. The practical examination was absent in the NCS 2.

**b. The relative depth and breadth of the content covered in the respective curricula**

Both curricula show decreasing breadth and increasing depth between Grade 10 and 12. The CAPS has reduced both breadth and depth of content in Grade 12 relative to the NCS 2, but examines one topic from Grade 11 in Grade 12.

The reduction in depth and breadth in the CAPS has resulted in loss of some important conceptual progression, e.g., omitting descent with modification from Grade 11, reducing the importance of biogeography, and omitting comparative anatomy has weakened the conceptual development of evolution. On the other hand, the re-ordering of life processes between Grade 10 and Grade 11 makes more sense conceptually.

**c. The overall design, structure and coherence of the curricula.**

The overall design of the NCS 2 is an outcomes-based, competence curriculum. The structure is informed by three LOs, although this approach is weakened in the Examination Guidelines (Doc 1.7), where content and skills are listed without reference to LOs. The various curriculum documents are coherent, in that they retain LOs as a feature of curriculum and assessment, but each re-contextualisation diverges from the original intent. Practitioners consider that successive documents provide greater clarity and are more concise. The document that teachers and subject advisors find most useful is the Examination Guidelines.

The CAPS is a syllabus-type, performance curriculum. The structure is informed primarily by the content, although the SAs guide the selection of content and investigations. There is presently one curriculum document that is coherent with respect to the aims, the selection of content and the supporting activities.

**d. The level of specification of various aspects of the curricula**

The different documents associated with the NCS 2 give increasing levels of specification. The content framework (Doc 1.5) gives a recommended sequence of knowledge areas, but does not prescribe pacing. Its associated Examination Guidelines for Grade 12 (Doc 1.7) change the recommended sequencing, and prescribe pacing in the form of a Year Planner. The sequence in which content is taught is linked to the examination papers at the end of Grade 12, i.e., Paper 1 examines work taught in the early part of the year, and Paper 2 examines work taught in the latter part of the year.

The CAPS provides a recommended sequence, but allows for the option of teachers deviating from the recommended sequence. Time allocations are given for each main topic throughout the year. The sequence in which topics are taught are not linked to the examination papers, since each examination paper examines topics taught in all four terms according to the recommended sequence.

With the documents available at present, the NCS 2 exam guidelines (Doc 1.7) provided more detailed content listing than the New Content Framework (Doc 1.5). The level of detail for common topics in the CAPS and the NCS 2 (Doc 1.5) is very similar.

**e. The guidance provided by the curricula for the teaching and assessment of the subject.**

Both curricula provide very little guidance with regard to pedagogy. Very detailed guidance is provided for assessment in the Subject Assessment Guidelines (Doc 1.3), Examination Guidelines (Doc 1.7) and the Assessment chapter in the CAPS (Doc 2.1). The assessment guidance includes the number and types of formal assessment tasks in each term, and the weighting of SBA relative to final examinations. Detailed guidelines are provided for the structure of examination papers, with respect to allocation of marks per topic and per cognitive level. Since performance of the whole education system is evaluated by examination results, delivery is strongly assessment-driven. Thus, although both the NCS 2 and the CAPS allow for teachers to deviate from the prescribed sequencing and pacing, the centralisation of assessment inhibits teachers from exercising this freedom.

The powerful end-of-year examinations dictate sequencing, since teachers divide the content according to which examination paper it is tested in, rather than what makes best conceptual sense. This unwanted 'backwash effect' of two examination papers is a cause for concern.

The over-riding limiting factor to curriculum implementation is the competence, confidence and motivation of teachers. Stringent assessment requirements are used to monitor teachers' compliance with the assessment requirements of each curriculum.

## 2.14 RECOMMENDATIONS

### Timeframes and consultation process

Both the NCS 2 and the CAPS were written and published in a relatively short timeframe, with the result that errors, omissions and lack of clarity were still present when the documents were published. Policy documents should be distributed for comment and critical reading before they are printed, distributed and implemented. This will reduce the necessity for circulars correcting errors and changing aspects of the curriculum.

The rapid succession of curriculum change since 2006 has had a detrimental effect on Life Sciences teachers, who are understandably confused about which curriculum is current in each Grade. Even though there may be flaws in the CAPS curriculum, it should not be changed for at least ten years. The subject desperately needs some stability so that teacher confidence, competence and motivation can grow. In that time, it is hoped that teachers will grow in their capacity to incorporate practical work into Biology teaching, and to administer their own assessment tasks. The role of subject specialists should change to being academic leaders rather than monitors of assessment.

### Specialist curriculum unit and format of curriculum

There is a case to be made for a specialist curriculum unit tasked with drawing up curriculum. If the format of the Examination Guidelines is the one that is most useful to teachers and textbook writers, the curriculum document should follow that format. There should not be a cascade of progressively more explicit documents, leading to confusion about which document is official policy.

The format of content statements should be changed to take the form of a sentence with an action verb, indicating what learners should be able to do with the content. Two examples are given from the Lesotho General Certificate of Secondary Education (2013):

> *Candidates should be able to*
>
> *o) compare the different structural adaptations of insect-pollinated and wind-pollinated flowers;*
>
> *p) describe the growth of the pollen tube and its entry into the ovule followed by fertilization (production of endosperm and details of development are NOT required).*

The whole Lesotho curriculum for the General Certificate of Secondary Education is written in this format. By contrast, the Examination Guidelines (Doc 1.7, p 11) list content in the following format:

> *Examples of the application of Darwin's theory (such as the long neck of giraffe or the legs of snakes)*
>
> *Speciation as a mechanism for producing new species.*

### Teachers' responsibility for implementing change

Through informal discussion and responses to specific questions during this evaluation, the evaluation team leader became aware that subject specialists and lead teachers undertake a large amount of monitoring of teachers. This is regarded as necessary at present because many Life Sciences teachers are not qualified to teach the subject, or have recently graduated and lack confidence and competence in teaching and assessing the subject. Lifelong learning has long been one of the seven roles and competences of teachers, and should be used to encourage teachers to become self-regulated learners themselves. The current trend towards centralisation should be reversed, so that teachers develop the competence and confidence to structure their curriculum sequence, pacing and assessment to suit their own contexts. The current trend to centralisation of these decisions promotes a passive teaching force.

The re-instatement of practical work into the Life Sciences curriculum is very welcome, and time should be allowed for it to become firmly entrenched in the professional practice of Life Sciences teachers. Few South African teachers have experienced the value of practical work in increasing learners' motivation, enjoyment and understanding of the subject. Teacher support materials will be necessary to promote this initiative. However, teachers should take responsibility for their own development in this regard.

# 3 LIFE SCIENCES: EXIT-LEVEL OUTCOMES FOR THE FET PHASE CAPS

The exit-level outcomes for the FET Phase for the CAPS were determined. Table 27 below reflects the topics that are covered in the Life Sciences CAPS for the FET Phase.

**Table 27: Exit-Level Outcomes for Topics in the CAPS**

| Generic topics and sub-topics | Gr 10 | Gr 11 | Gr 12 | Exit-level outcomes for FET (content / skills / competencies): At the end of the FET Phase, learners will be able to: |
|---|---|---|---|---|
| **A Nature and history of science** | | | | |
| | Y | | Y | Describe the **history** of some important theories and discoveries in Life Sciences, e.g. structure of DNA, microscopes, Mendel's contribution, evolution, human evolution, classification<br>Understand the nature of science, e.g. differentiate hypothesis and theory; reasoning in science; process of scientific investigation |
| **B Molecular and cell biology** | | | | |
| B1 Molecules of life | Y | | | Explain the structure and functions of biologically important molecules in cells and in the human diet. |
| B2 Cell structure | Y | | | Relate structure and location of organelles to their function.<br>Differentiate between plant and animal cells; prokaryotes and eukaryotes<br>Explain the concept of a tissue<br>Relate structure and location of tissues to their functions |
| B3 Energy and metabolism | Y | | | Explain structure and function of enzymes and their role in metabolism<br>Explain movement of molecules across the membranes |
| B4 Capturing energy | | Y | | Describe the process and importance of photosynthesis<br>Explain the effects of environmental factors on the rate of photosynthesis and the application thereof in greenhouse systems.<br>Describe the role of ATP in a cell. |
| B5 Releasing energy | | Y | | Describe the process and importance of cellular respiration<br>Compare aerobic and anaerobic respiration |
| **C Genetics and Heredity** | | | | |
| C1 DNA structure and function | Y | | Y | Describe the structure, location, role and replication of DNA |
| C2 Gene expression and control | | | Y | Describe the structure, types, location of RNA and its role in protein synthesis.<br>Describe and apply the genetic code |
| C3 Cellular reproduction | Y | | Y | Describe the process, purpose and significance of mitosis and meiosis.<br>Differentiate between mitosis and meiosis.<br>Explain the place of mitosis in the cell cycle. |
| C4 Patterns of inheritance | | | Y | Explain the consequences of abnormal meiosis<br>Explain the role of genes in inheritance and variation<br>Solve genetics problems involving monohybrid and dihybrid crosses, complete and incomplete dominance, codominance, blood groups, sex-linked inheritance.<br>Explain gene and chromosomal mutations and their effects.<br>Link mutations with natural selection. |

| Table 27: Exit-Level Outcomes for Topics in the CAPS (continued) | | | | |
|---|---|---|---|---|
| **Generic topics and sub-topics** | **Gr 10** | **Gr 11** | **Gr 12** | **Exit-level outcomes for FET (content / skills / competencies):** At the end of the FET Phase, learners will be able to: |
| C5 Biotechnology | Y | | Y | Explain the process of genetic engineering and its applications.<br>Explain the use of genetic technologies in tracing genetic links, paternity testing and DNA fingerprinting.<br>Explain the use of medical biotechnologies in the treatment of cancer.<br>Describe the application of biotechnology in everyday life, e.g. enzymes in washing powder. |
| **D Evolution and Diversity** | | | | |
| D1 Evidence of evolution | Y | | Y | Describe various lines of evidence for evolution, e.g. fossil record, descent with modification, genetics, and biogeography.<br>Identify main fossil sites in South Africa and their significance. |
| D2 Biodiversity and classification | Y | | | Appreciate the extent of biodiversity in South Africa.<br>Explain and apply the principles of classification at the Kingdom level. |
| D3 Processes of evolution | | | Y | Describe Darwin's theory of evolution by natural selection and its application to current examples, e.g. DDT resistance, drug resistance.<br>Describe artificial selection as an illustration of natural selection and differentiate between the two.<br>Describe mechanisms of speciation and reproductive isolation. |
| D4 Diversity of bacteria, protists, fungi and viruses | | Y | | Describe the biodiversity, basic structure and general characteristics of bacteria, protists, fungi and viruses.<br>Explain their roles in the environment and in biotechnology.<br>Describe their roles as pathogens and the management of the diseases they cause. |
| D5 Plant diversity and evolution | | Y | | Explain evolutionary trends within the plant kingdom. |
| D6 Animal diversity and evolution | | Y | Y | Classify animal phyla according to features of their body plans.<br>Relate body plans to mode of life.<br>Compare body plans of six animal phyla.<br>Identify evolutionary trends within the animal kingdom.<br>Describe human evolution as understood currently. |
| **E Ecology** | | | | |
| E1 Population ecology | | Y | | Describe factors affecting population size.<br>Interpret population growth curves.<br>Describe intraspecific interactions and social organisation in populations.<br>Interpret human population growth curves and age-gender pyramids.<br>Predict effects of human population growth on the environment. |

| Table 27: Exit-Level Outcomes for Topics in the CAPS (continued) | | | | |
|---|---|---|---|---|
| **Generic topics and sub-topics** | **Gr 10** | **Gr 11** | **Gr 12** | **Exit-level outcomes for FET (content / skills / competencies):** At the end of the FET Phase, learners will be able to: |
| E2 Communities and ecosystems | Y | Y | | Describe the concept of an ecosystem structure and functioning.<br>Conduct a scientific investigation of a local ecosystem including the human impact on the ecosystem.<br>Explain energy flow through ecosystems and relationship to trophic levels.<br>Interpret flow charts of natural cycles in the environment.<br>Explain the role of invertebrates in agriculture and ecosystems.<br>Describe interactions within an ecological community, e.g. predation, competition, symbiosis.<br>Describe the process of ecological succession. |
| E3 The biosphere | Y | | | Explain the concept of the biosphere, and the inter-connectedness of its components.<br>Describe and locate different biomes in southern Africa. |
| E4 Human effects on the environment | Y | Y | | Describe the effects of fertilisers on the environment.<br>Describe human impact on the environment with special reference to South Africa, e.g. atmosphere and climate change, water availability and quality, loss of biodiversity, solid waste disposal, and food security. |
| **F Life processes in animals** | | | | |
| F1 Animal tissues and organs | Y | | | Relate structure of four basic animal tissues to their functions, with special emphasis on connective tissues, muscle tissue.<br>Identify parts of a long bone and describe its structure. |
| F2 Skeleton and muscles | Y | | | Explain different types of skeletons, citing advantages and disadvantages of each.<br>Identify components of the human skeleton and their functions.<br>Identify different types of joints, and the structure of the synovial joint.<br>Describe the role of components of the musculoskeletal system in movement. |
| F3 Circulation | Y | | | Describe the structure and functioning of the human circulatory system, including lymphatic system. |
| F4 Gaseous exchange | | Y | | List the requirements of an efficient gaseous exchange surface.<br>Relate the structure of gaseous exchange surfaces to the environment.<br>Describe the structure and functioning of the human gaseous exchange system.<br>Describe the effects of altitude on gaseous exchange in humans. |
| F5 Immunity | | Y | | Describe the concept of immunity and immune responses of plants and animals.<br>Explain how vaccinations work in immunity. |

| Table 27: Exit-Level Outcomes for Topics in the CAPS (continued) | | | | |
|---|---|---|---|---|
| **Generic topics and sub-topics** | **Gr 10** | **Gr 11** | **Gr 12** | **Exit-level outcomes for FET (content / skills / competencies):** At the end of the FET Phase, learners will be able to: |
| F6 Digestion and nutrition | | Y | | Relate mammalian dentition to mode of feeding.<br>Describe the structure and functioning of the human digestive system.<br>Relate a balanced human diet to good health. |
| F7 Excretion | | Y | | Describe the role of various organs in human excretion.<br>Describe the structure and functioning of the human urinary system. |
| F8 Nervous control and the senses | | | Y | Describe the structure and functioning of the human nervous system.<br>Describe the structure and functioning of the eye and ear. |
| F9 Endocrine control | | | Y | Identify and locate selected endocrine glands in the human body.<br>Describe hormones secreted by selected glands and their functions, including negative feedback. |
| F10 Reproduction and development | | | Y | Explain how different reproductive strategies contribute to reproductive success in vertebrates.<br>Structure and functioning of human reproductive systems.<br>Describe the stages of human sexual development and reproduction. |
| F11 Diseases, disorders and treatment in humans | Y | Y | Y | Describe some common diseases and disorders of the systems studied and their treatment, e.g. kwashiorkor, Alzheimer's disease, asthma, astigmatism, middle ear infections, cancer. |
| F12 Homeostasis | | Y | Y | Explain the concept of homeostasis and its significance in humans.<br>Describe homeostasis in digestion, gaseous exchange, excretion, and thermoregulation. |
| **G Life processes in plants** | | | | |
| G1 Plant tissues and organs | Y | | | Relate structure of plant tissues to their functions.<br>Describe the distribution of different plant tissues in the organs of the plant.<br>Describe secondary growth in plants. |
| G2 Transpiration & translocation | Y | | | Explain the process of transpiration and environmental factors that affect it.<br>Explain the processes of wilting and guttation.<br>Describe the path of water through the plant.<br>Describe the translocation of food in the plant. |
| G3 Reproduction and Development | | Y | | Distinguish between sexual and asexual reproduction.<br>State the advantages and disadvantages of asexual and sexual reproduction.<br>Describe flowers as reproductive structures.<br>Identify adaptations of flowers for different pollinators. |
| G4 Responses to the environment | | | Y | State the general functions of some plant hormones.<br>Explain the process and control of geotropism and phototropism.<br>Describe some plant defence mechanisms. |

| Table 27: Exit-Level Outcomes for Topics in the CAPS (continued) | | | | |
|---|---|---|---|---|
| **Generic topics and sub-topics** | **Gr 10** | **Gr 11** | **Gr 12** | **Exit-level outcomes for FET (content / skills / competencies):** At the end of the FET Phase, learners will be able to: |
| G5 Human uses of plants | | Y | Y | Describe how humans manipulate plants for their own benefit, e.g. weed control, seeds as a food source. |
| **H Indigenous knowledge** | | | | |
| | Y | Y | | State the use of traditional technology, e.g. traditional medicines and healers. |
| **I Relationship to work** | | | | |
| | Y | | | Demonstrate awareness of careers related to the Life Sciences. |
| **J Ethics, attitudes and values** | | | | |
| | Y | | | Demonstrate awareness of relevant ethical issues, e.g. stem cell research, cloning. |
| **U Unclassified** | | | | |
| | | Y | | |

## 3.1 EXIT LEVEL SKILLS

The exit level skills are described under the three SAs (Doc 2.1, pp 13 - 18). At the end of the FET Phase, learners should be able to:

### 3.1.1 SA 1: Knowing Life Sciences

#### *3.1.1.1 Acquire knowledge*

- Access information from a variety of sources
- Select key ideas
- Recall facts
- Describe concepts, processes, phenomena, mechanisms, principles, theories, laws and models in Life Sciences

#### *3.1.1.2 Understand and make connections between ideas and concepts to make meaning of Life Sciences*

- Build a conceptual framework of science ideas
- Organise or reorganise knowledge to derive new meaning
- Write summaries
- Develop flow charts, diagrams and mind maps
- Recognise patterns and trends.

#### *3.1.1.3 Apply knowledge on [sic] Life Sciences in new and unfamiliar contexts*

- Use information in a new way
- Apply knowledge to new and unfamiliar contexts

#### *3.1.1.4 Analyse, evaluate and synthesize scientific knowledge, concepts and ideas*

- Analyse information/data
- Recognise relationships between existing knowledge and new ideas
- Critically evaluate scientific information
- Identify assumptions
- Categorise information.

### 3.1.2 SA 2: Investigating phenomena in Life Sciences

#### *3.1.2.1 Follow instructions*

#### *3.1.2.2 Handle equipment / apparatus*

#### *3.1.2.3 Make observations*

- Drawings
- Descriptions
- Grouping of materials or examples based on observable similarities and differences
- Measurements
- Comparing materials before and after treatment
- Observe results of an experimental investigation which will involve recording information in an appropriate way
- Counting

#### *3.1.2.4 Record information or data*

- Include observations or information as drawings, descriptions, in simple table format, as simple graphs, etc

#### *3.1.2.5 Measure*

- Measure accurately using appropriate instruments
- Estimate

#### *3.1.2.6 Interpret*

- Change data from one form to another
- Perform calculations
- Interpret tables and graphs
- Apply theory to practical situations
- Recognise patterns/ trends
- Appreciate limitations of investigative procedures
- Make deductions based on evidence

#### *3.1.2.7 Design/ plan investigations or experiments*

- Identify a problem
- Hypothesize
- Select apparatus or equipment and/or materials
- Identify variables
- Suggest ways of controlling variables
- Plan an experiment
- Suggest ways of recording results
- Understand the need for replication or verification

### 3.1.3 SA 3: Appreciate and understand the history, importance and applications of Life Sciences in society.

- Understand the history and relevance of some scientific discoveries
- The relationship between indigenous knowledge and Life Sciences
- The value and application of Life Sciences knowledge in the industry in respect of career opportunities and in everyday life.

Skills are the same as for SA 1.

## 3.2 DISCUSSION

**Appropriateness of the emphasis in terms of the broad content areas**

The content areas selected for the FET Phase are an appropriate reflection of the scope of biological sciences at an introductory level. The section on human impact on the environment has taken time away from deeper study of the discipline of ecology. This topic is more appropriate in Geography, where it is already studied. The topics chosen under ‘human impact on the environment’ are of global significance, and have value in that they allow for the development of critical thinking skills.

### Key content omitted or incorrect at exit-level from the FET Phase

1. The role of exercise in the health of the musculoskeletal system has been omitted. We consider this to be important for everyday life and health.
2. Structure of blood has been omitted, and is necessary to understand the immune system. It is signalled early in the CAPS (p 28), with a reference that it will appear later, but it is not present under the circulatory system or elsewhere.
3. An error has been perpetuated in the use of ‘modification by descent’ (p 61) instead of ‘descent with modification’. The concept is omitted in the CAPS. This is a significant omission, because it is a foundational concept for evolution.
4. The use of ‘unique human characteristics of reproduction’ (p 56) is incorrect, since the characteristics described below that heading are not unique to humans.
5. Translocation (p 29) is located under the heading ‘guttation and wilting’, which itself is a subheading under ‘transpiration’ whereas translocation is a distinct process from any of the others.
6. Traditional technologies (p 39) are listed as beer, cheese and wine, which are not indigenous technologies.
7. Significance of seeds (p 40) has been interpreted as the use of seeds as food sources, seed banks, and endemic species in South Africa. The significance of seeds *in the evolution of plants* has been omitted. ‘Endemic species in South Africa’ does not make sense.
8. A misconception is presented in the section on skeletons (p 30), where teachers are asked to emphasise the developmental progression within three types of skeletons. The three types chosen illustrate adaptations to different lifestyles, and do not form an evolutionary sequence, as implied,
9. The purpose of meiosis (p 55) is recorded as gametogenesis, which is incorrect. The consequence of meiosis is halving the number of chromosomes.
10. It is unclear why the CAPS requires learners to study a list of South African fossil sites and palaeoanthropologists who have worked there (p 65).
11. The inclusion of Lamarck and punctuated equilibrium (p 61) is inappropriate at this level of study, because it is unfamiliar to the teachers and likely to be misrepresented.
12. The phrase ‘theories of development’ (p 61) is incorrectly used here and should be omitted or changed to ‘theories of evolution’

**Appropriateness of skills/competencies specified across the whole phase, and changes that are recommended**

The skills listed under SA1, SA2 and SA3 in the CAPS are broadly appropriate for the Life Sciences, with the following reservations:

1. It is unclear whether the CAPS aligns itself with the original Bloom's taxonomy of cognitive demand or the Revised Bloom's Taxonomy, or neither (Doc 2.1, p 67). Differences are evident in the use of verbs to identify cognitive processes in the Revised Bloom's Taxonomy (remember, understand, apply, analyse, evaluate, create), whereas the original Bloom's taxonomy uses nouns (knowledge, comprehension, application, analysis, synthesis, evaluation) (Krathwohl, 2002). The CAPS uses remembering, understanding, applying, evaluating, analysing and synthesizing knowledge as its cognitive processes (Doc 2.1, p 67), but retains the order of the original Bloom's taxonomy (synthesis follows evaluate, which is reversed in the Revised Bloom's Taxonomy). This confusion is also evident in the description of sub-aim 2.5.1.3 (Doc 2.1, p 14), where 'apply knowledge on [sic] Life Sciences in new and unfamiliar contexts' is listed under SA1. This is correct in terms of the original Bloom's Taxonomy, but not in terms of the description of the cognitive process 'apply' in the Revised Bloom's Taxonomy. The Revised Bloom's Taxonomy interprets 'apply' as 'implementing' or 'executing' a procedure (Krathwohl, 2002), i.e. it would align more closely to SA2 than to SA1. The CAPS sits between the Revised Bloom's Taxonomy and the original Bloom's taxonomy, rather than aligning clearly with one or the other.
2. The skills 'make observations', 'record information and data' and 'measure' overlap Making observations is a very important scientific skill, but it cannot be demonstrated without recording the observations, either orally, or by means of drawings, descriptions, measurements. These two skills should be collapsed into one. Likewise, measuring is one of the ways of recording information and data, and should be collapsed into the same skill.
3. The skill 'design/plan investigations' is an opportunity to synthesize many of the skills practised individually. However, on p 16 where Skill 2.5.2.7 (Design/Plan Investigations or Experiments) is described, there is no requirement to carry out the designed investigation, collect and interpret data, and draw conclusions. Where investigations are listed in the detailed content section of the CAPS (Doc 2.1, pp 21-65), learners are required to design investigations and record their observations. There is therefore a mismatch between the description of Skill 2.5.2.7 and its implementation in the curriculum content section. The prescribed investigations in the content section are more appropriate to the nature of science than the description of Skill 2.5.2.7.

**Appropriateness of the emphasis on cognitive skills implied across the whole phase**

Cognitive levels overall are satisfactory. The use of models such as the Fluid Mosaic Model (p 25) and the Lock-and key Model (p 24) illustrate the need to engage with higher order thinking.

# 4 PHYSICAL SCIENCES: A COMPARISON OF THE NCS AND CAPS FOR THE FET PHASE


| | |
|---|---|
| **Evaluators** | Dr Sharon Grussendorff<br>Miss Nompumelelo Zuma<br>Mrs Mmapaseka Stephen<br>Ms Akeda Isaacs<br>Dr Andrè van der Hoven |


## 4.1 INTRODUCTION

Physical Sciences is a subject that makes use of scientific enquiry and problem solving techniques to investigate physical and chemical phenomena. It incorporates the disciplines of Physics and Chemistry. As such it needs to prepare learners for future studies in both of these disciplines, as well as in related disciplines.

Physical Sciences prepares learners for effective living in a modern technological environment by providing foundational knowledge of scientific and technological processes, and outlining the effects of science on society and the environment. It promotes broad scientific literacy beyond just the requirements of the disciplines, and requires numerical, practical and verbal skills. Physical Sciences makes use of models, theories and laws to explain and predict natural phenomena. It requires rigour of thought and practice, and a certain amount of memorisation, since it relies on technical terminology and understanding of basic concepts. The subject involves application of theory to everyday life, and depends on a natural curiosity and well-developed observational skills.

Physical Sciences plays an important role in the FET Phase, and in society at large, since it underpins all technical and scientific development and is therefore very important for economic development. It promotes critical and logical thinking, as well as sequential reasoning processes, and provides a practical context in which mathematics may be applied, thus providing a good integration platform. The practical and investigative components of the subject develop an ability to plan systematically, and the need to take into account limitations and safety concerns.

## 4.2 LIST OF DOCUMENTS ANALYSED

The evaluation team consulted six documents relating to the NCS and three documents that define the CAPS. These are listed in Table 28. Each document is given a reference code which is used when referring to it throughout the rest of this report.

| Table 28: Referenced documents | |
|---|---|
| **1 National Curriculum Statement (NCS)** | |
| Department of Education. 2003. *National Curriculum Statement for Grades 10-12 (General): Physical Sciences.* | Doc 1.1 |
| Department of Education. 2008. *National Curriculum Statement for Grades 10-12 (General): Learning Programme Guidelines - Physical Sciences.* | Doc 1.2 |

| Table 28: Referenced documents (continued) | |
|---|---|
| **1 National Curriculum Statement (NCS)** | |
| Department of Education. 2008. *National Curriculum Statement for Grades 10-12 (General): Subject Assessment Guidelines - Physical Sciences.* | Doc 1.3 |
| Department of Education. 2009. *National Curriculum Statement for Grades 10-12 (General): Examination Guidelines - Physical Sciences with Addendum (2010)* | Doc 1.4 |
| Department of Education. 2006. *National Curriculum Statement for Grades 10-12 (General): Physical Sciences Content Document.* | Doc 1.5 |
| Department of Education. 2003. *National Curriculum Statement for Grades 10-12 (General): Overview Document.* | Doc 1.6 |
| **2 Curriculum and Assessment Policy Statement (CAPS)** | |
| Department of Basic Education. 2011. National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement ( CAPS ) Further Education and Training Phase Grades 10-12 Physical Science | Doc 2.1 |
| Department of Basic Education. (n.d.) National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement. Gr R – 12 | Doc 2.2 |
| Department of Basic Education. (n.d.) National Protocol for Assessment. Gr R – 12. | Doc 2.3 |

## 4.3 BROAD CURRICULUM DESIGN, FORMAT AND USER-FRIENDLINESS OF CURRICULUM DOCUMENTATION

Table 29 below indicates the number of subject-related documents for Physical Science for the NCS and the CAPS. Also indicated is the total number of pages in all the subject-related documents together.

The documents were assessed for their user-friendliness using a scale from good to poor[15].

The accessibility of the language used in the documentation was also assessed, using a different scale[16].

The alignment between the various documents was assessed using a set of codes[17].

Finally, the central design principle of the curriculum was identified and is indicated in the last row of Table 29.

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15 **Good:** Very user-friendly - the function and the structuring of the documents is clear
**Moderate:** Moderately user-friendly - the function and the structuring of the documents is sometimes clear and at other times the function is unclear or the structuring confusing
**Poor:** Not user-friendly - the function and the structuring of the documents is often unclear or the structuring is overly complex

16 **Good:** Very accessible language - the documents use plain, direct language
**Moderate:** Moderately accessible language - the documents sometimes use plain, direct language and at other times the language is complex or obscure or terms are ill-defined
**Poor:** Inaccessible language - the documents often use complex or obscure language and terms that are not defined

17 **Good:** Good alignment - it is clear how documents relate to one another and complement one another
**Moderate:** Moderate alignment - it is sometimes clear how documents relate to one another; there are some contradictions across documents or there are instances where it is not clear how documents complement or relate to one another
**Poor:** Poor alignment - it is not clear how documents relate to one another. There are contradictions across documents, or it is not clear at all how documents complement one another

| Table 29: Broad design, format and user-friendliness | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Number of documents (subject-related)** | 5 | 1 |
| **Total number of pages (in subject-related documents)** | 75 (Doc 1.1) +<br>31 (Doc 1.2) +<br>18 (Doc 1.3) +<br>34 (Doc 1.4) +<br>116 (Doc 1.5)<br>**TOTAL = 274** | 164 (Doc 2.1)<br>**TOTAL = 164*** |
| **User-friendliness (Good/moderate/poor)** | Poor | Moderate |
| **Accessibility of language (Good/moderate/poor)** | Moderate | Good |
| **Alignment (Good/moderate/poor)** | Poor | Moderate |
| **Central design principle (the technical curriculum design aspect that organises the curriculum)** | Outcomes-based | Content-based |

** This excludes a future Examination Guidelines document which is due for release in 2014.*

The **length** of the CAPS document is appropriate since the details that are provided with respect to content clarification and teaching and assessment guidelines are regarded as essential for effective learning of the subject. A similar set of guidelines is presented in Document 1.5 of the NCS, but the multiplicity of documents led to a great deal of confusion and variation in delivery. In practice, the Examination Guideline document (Doc 1.4) was used by teachers as the primary source of guidance for their teaching at the Grade 12 level.

The CAPS document also includes clear guidance on subject-specific assessment which will further clarify, and provide consistency to assessment practices in classrooms around the country.

The **user-friendliness** is regarded as poor for the NCS because contradictory guidance is given in the documentation for teaching and assessment. For example, where the original (2003) NCS document (Doc 1.1, pp 41, 43) and the content document (Doc 1.5, pp 91, 95) prescribe the wave nature of matter and digital electronics as essential topics, the Examination Guidelines (Doc 1.4) does not include these. In some regards the CAPS may be considered to be user-friendly, because the content clarification and guidance is very clear and complete. However, due to the rush in implementation of the CAPS, the current version of the document contains a great number of errors (see Section 4.6 for examples), as not enough time was allowed for thorough conceptual- or language editing. The team therefore concluded that the document is only moderately user-friendly.

The **language** in the NCS is considered to be moderately accessible, because the educational jargon used in the documentation is complex. For example, *'Subjects in the Fundamental Learning Component collectively promote the achievement of the Critical and Developmental Outcomes, while specific subjects in the Core and Elective Components individually promote the achievement of particular Critical and Developmental Outcomes'* (Doc 1.1, p 5). The language used in the CAPS is clear, and contains very little unnecessary jargon. The numerous errors and inconsistencies, however, do detract from the clarity of the language in the document.

The **alignment** in the NCS is regarded as poor because of repetition across the documents, and contradictions between the Examination Guidelines document (Doc 1.4) and the Subject Assessment Guidelines document (Doc 1.3), the original (2003) NCS document (Doc 1.1) and the content document (Doc 1.5). Alignment in the CAPS is moderate, since, although there is only one subject-related document, there have been a number of versions of this document that have been released, and these have not been dated, so it is difficult for teachers or other users of the document to know if they are working with the correct version or not. It is further understood that an Examinations Guideline document is to be released prior to the Grade 12 examinations of 2014, so it remains to be seen whether this document will be well aligned with the Physical Science CAPS document.

## 4.4 CURRICULUM OBJECTIVES

The objectives of the NCS and the CAPS were identified from the introductory section to the subject in each document. In the NCS, these objectives were located under the 'Purpose' and 'Scope' headings (Doc 1.1, pp 9 - 10). In the CAPS, the objectives were located under the 'Specific Aims' heading (Doc 2.1, p 8). The objectives are indicated with a (Y) for the curriculum where these are mentioned.

**Table 30: Subject-specific aims / objectives of the curricula**

| Objectives | NCS | CAPS |
|---|---|---|
| Make learners aware of the environment | Y | Y |
| Equip learners with investigation skills | | Y |
| Promotes knowledge and skills in scientific inquiry and problem solving | Y | Y |
| Promotes construction of scientific and technological knowledge | Y | Y |
| Promotes application of scientific and technological knowledge | Y | Y |
| Promotes understanding of the nature of science and its relationships to technology, society and the environment | Y | Y |
| Prepares learners for future learning | Y | Y |
| Prepares learners for specialist learning | Y | Y |
| Prepares learners for employment | Y | Y |
| Prepares learners for citizenship | Y | Y |
| Holistic development of learners | Y | Y |
| Prepares learners for socio-economic development | Y | Y |
| Prepares learners for environmental management | Y | Y |
| Prepares learners who influence scientific and technological development in SA | Y | Y |
| Importance of Indigenous Knowledge Systems | Y | Y |
| Fosters ethical and responsible attitude towards learning, constructing and applying Physical Sciences | Y | |

| Table 30: Subject-specific aims / objectives of the curricula (continued) | | |
|---|---|---|
| **Objectives** | **NCS** | **CAPS** |
| Accommodates reflection and debate on its findings, models and theories. | Y | |
| Corrects historical limitations | Y | |
| Prepares learners to work in scientific ways | Y | |
| Stimulates curiosity and interest in natural and physical world | Y | |
| Guides learners to reflect on the universe | Y | |
| Develops insights and respect for different scientific perspectives and a sensitivity to cultural beliefs, prejudices and practices in society | Y | |
| Develops useful skills and attitudes that will prepare learners for various situations in life, such as self-employment and entrepreneurial ventures | Y | |

The NCS and the CAPS cover similar objectives with regard to the construction and application of scientific knowledge to the lives of learners, and to the environment and society. Where the objectives differ are where the NCS refers to issues related to socio-political and ethical awareness, for example '*correcting some of these historical limitations*', '*ethical and responsible attitude*', and '*sensitivity to cultural beliefs, prejudices and practices in society*' (Doc 1.1, pp 9 - 10). In addition the NCS mentions development of skills related to self-employment and entrepreneurial ventures, which are not mentioned at all in the CAPS document. In brief, the objectives of the CAPS document are more traditional, and less idealistic, than those in the NCS.

## 4.5 CONTENT / SKILL COVERAGE: BREADTH AND DEPTH

This section addresses curriculum coverage by comparing the content, concepts and skills that are covered in each curriculum. This is done by considering the **breadth** (the number of topics and/or sub-topics represented in the curricula) and the **depth** (the complexity and extent of cognitive challenge associated with the topics).

### 4.5.1 Coverage (Breadth)

#### *4.5.1.1 Content Coverage*

Table 1 in Annexure B shows the content statements represented for the FET Phase for the NCS and the CAPS. Table 31 below presents a summary of the breadth of content for each grade, and for the whole FET Phase, for each curriculum. In addition, since not all Grade 12 material was examinable in the NCS, the breadth of examinable content is also shown.

| Table 31: Breadth of content in the curricula | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NCS | | | | | CAPS | | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric Exam | FET Phase | Gr 10 | Gr 11 | Gr 12 | Matric Exam | FET Phase |
| Total number of sub-topics | 46 | 53 | 52* | 55 | 151* | 48 | 37 | 32 | 52 | 119 |

* *16 of these topics were never examined, and therefore never actually taught in practice*

It should be noted that the number of examinable topics in Matric for the NCS is greater than that covered in Grade 12, since the examinable content includes some Grade 10 and 11 topics. Figure 7 below represents the comparison of the relative breadth of each grade for the NCS and the CAPS. The non-examinable content is shown with a lightly shaded block for the NCS.

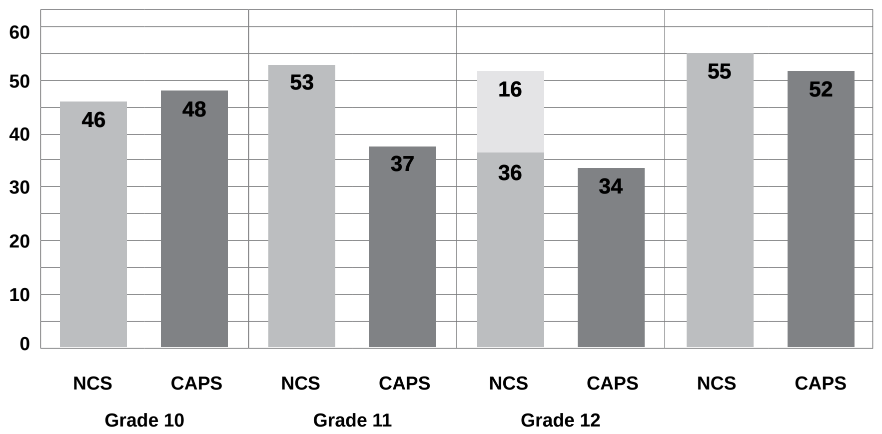


**Figure 7: Total number of topics per grade**

From this graph the following points can be noted:

- The content at **Grade 10** level is similar for both curricula, with a slight increase in the CAPS. Since concerns were raised in a previous Umalusi report (Umalusi, 2010a) regarding the breadth of the NCS content, the evaluation team considers the breadth of content in the CPS Grade 10 to be too extensive.

- The number of topics at **Grade 11** level is greatly reduced from the NCS to the CAPS, from 53 to 37 topics respectively. The evaluation team considers this to be an appropriate breadth of content, to allow for an increasing depth of engagement with the content. However, in practice, it is reported to be very difficult to cover all of the work required in the amount of time allocated over the year, since the time allocations provided in the CAPS document are in some cases unrealistic. For example, the time allocated to the first term's work totals 43 hours, but if one allows the last week of the term to be used for assessment, there are, in practice, fewer than 40 hours of actual teaching time available. The time allocations are scrutinised in more detail in section 4.8 (curriculum pacing).

- The number of topics covered at **Grade 12** level is similar for both curricula, with a slight reduction from the 36 topics in the NCS to 34 in the CAPS. (This total excludes the 16 topics which were not ever examined in the NCS.) Again the evaluation team considers this to be an appropriate breadth of content, to allow for greater depth development as well as allowing adequate time for revision for the final examination (including of the Grade 11 work which is examinable in the Grade 12 examination).

- The number of topics in the NCS **Grade 12 examination** (55) is slightly greater than those covered in the CAPS Grade 12 examination (52), but this difference is not very great, and is not likely to impact negatively on learner performance. (The number of examinable topics is greater than those in the Grade 12 NCS curriculum because the examinations include topics from Grade 11).

Figure 8 below represents the comparison of the relative breadth of the specified content for the whole FET Phase. Again the non-examinable content that is specified in the NCS is indicated with a lightly shaded block.

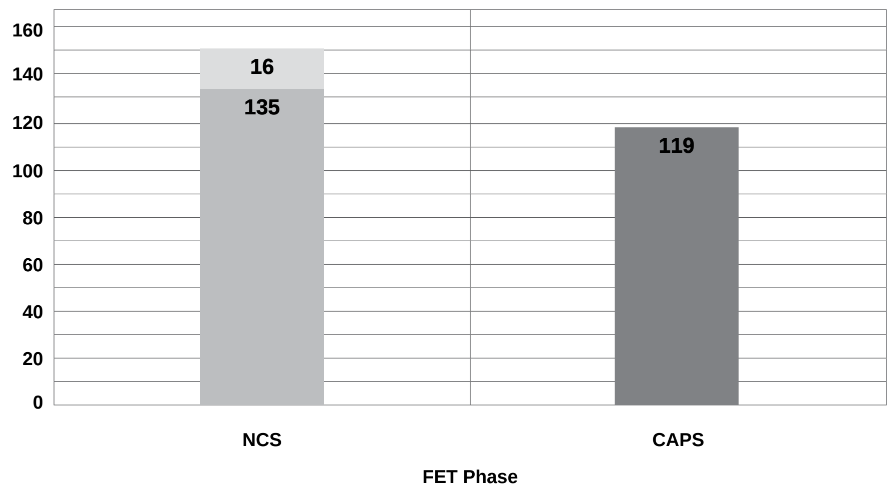


**Figure 8: Total number of topics per phase**

The **overall breadth** has been reduced from the NCS to the CAPS, from 135 to 119 sub-topics (if one takes only the examinable topics into account for the NCS). This reduction in breadth is a welcome shift, since a previous Umalusi study (Umalusi, 2010a) found the NCS curriculum to be too broad in comparison with equivalent international qualifications. In particular, this reduction in breadth is welcome for learners who are learning in a second or third language, as the greater breadth of the NCS meant that these learners were more severely disadvantaged due to the time constraints and greater amount of reading involved.

#### *4.5.1.2 Skill Coverage*

The skills in the **NCS** curriculum are encapsulated in the ASs associated with the three LOs (Doc 1.1, pp 18 - 33). These are listed below for Physical Science:

**LO1: Scientific Inquiry and Problem-solving Skills**

AS1: Conducting an investigation

AS 2: Interpreting data to draw conclusions

AS 3: Solving problems

AS 4: Communicating and presenting information and scientific arguments

**LO 2: Constructing and applying scientific knowledge**

AS 1: Recalling, stating and discussing specified concepts

AS 2: Explaining relationships

AS 3: Applying scientific knowledge

**LO 3: The nature of science and its relationship to technology, society and the environment**

AS 1: Evaluating knowledge claims

AS 2: Evaluating the impact of science on human development

AS 3: Evaluating the impact of science on the environment and sustainable development

As is evident from this list, these skills are described in a very generic way. The intention is that these will become more specific to the content area at the level of classroom practice, and will be integrated with the content throughout the course. However, a teacher who is not familiar with the specific skills related to Physics and Chemistry will not incorporate these into his/her teaching. The conclusion of the evaluation team is that the skills are underspecified in the NCS.

The CAPS is much more specific in the outlining of skills, which are detailed through the content outline and practical and teaching guidelines given in the curriculum (Doc 2.1, pp 15 - 142). The evaluation team identified particular skills from the document, and noted the number of times these skills are mentioned. (If skills are duplicated under a content topic they were only counted once). Table 2 in Annexure B presents the number of specific scientific skills per grade and across the FET Phase for the CAPS. Table 32 below is a summary of the total number of skills mentioned per broad skill area.

| Table 32: Skills covered in CAPS FET Phase | | | | |
|---|---|---|---|---|
| Type of skill area | Number of times the skill area is stipulated | | | |
| | Gr 10 | Gr 11 | Gr 12 | FET Phase |
| Problem solving skills | 21 | 18 | 13 | 52 |
| Experimental skills | 72 | 49 | 61 | 182 |
| Diagrammatic / Graphical / Tabular | 14 | 12 | 18 | 44 |
| Descriptive / Written | 105 | 66 | 71 | 242 |
| **Total stipulation of skills** | **212** | **145** | **163** | **520** |

A representation of the proportionate percentage of skills is shown in Figure 9 below:

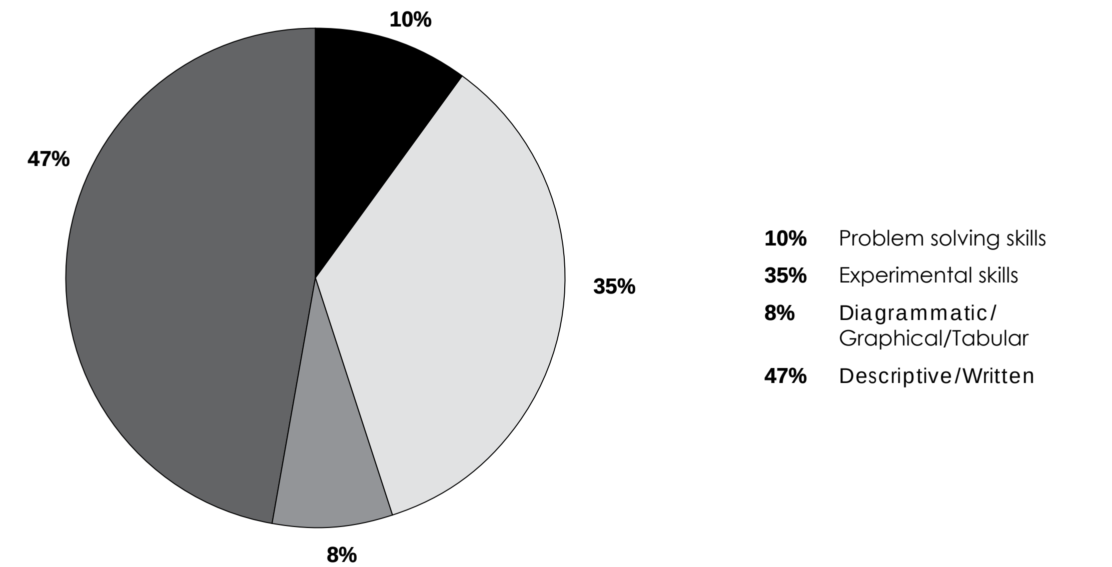


**Figure 9: Skills stipulated in CAPS teaching plans**

From this data one can conclude the following:

- Stipulation of **problem solving** skills is under-represented over the whole phase. The preamble in the CAPS document does mention that learners should do at least two problem solving exercises on a daily basis (Doc 2.1, p 9), but if a teacher closely follows the work schedule provided in the physical science content outline (Doc 2.1, pp 15 - 142), there is no guarantee that this skill will develop
- The stipulation of problem solving tapers across the phase, and is only mentioned in 13 out of a total of 32 topics in Grade 12.
- The under-specification of problem solving activities is problematic because physical science is largely a problem solving activity, relying on both mathematical and argumentative problem solving. These skills therefore need to be developed more intentionally than is outlined in the CAPS document.

- A suggestion is that the teaching guidelines could incorporate regular ideas and brief examples of specific problem solving activities related to the content to ensure that this important skill is well developed.

- **Unit conversions** are mentioned very seldom (once in Grade 10, once in Grade 11 and not at all in Grade 12). This is a fundamentally important skill which should be revisited very frequently to ensure mastery. An understanding of unit conversions also enables learners to grasp orders of magnitude and physical quantities, all of which are important foundational scientific concepts. It is recommended that problems and contexts involving unit conversions are more explicitly outlined in the teaching guidelines in the CAPS document.

- **Diagrammatic skills**, which include representation of data in tabular and graphical form, are also under-represented across the whole FET Phase. Since these skills are fundamental for all future scientific studies, it is important that these be well developed in learners.

- It is recommended that more explicit mention be made of **graphical and tabular skills**, and that these be incorporated into more of the activities and content descriptions.

- **Experimental skills** are well covered throughout the phase. The table below details the number of experimental activities or demonstrations which are recommended in the CAPS:

**Table 33: Recommended experimental activities and demonstrations**

| | Gr 10 | Gr 11 | Gr 12 | FET Phase |
|---|---|---|---|---|
| Recommended | 30 | 24 | 23 | 77 |
| Prescribed | 4 | 3 | 4 | 11 |

- A total of 77 practical tasks is considered sufficient across the FET Phase.

- **Written work** in the form of descriptions, discussions, explanations and reports is over-represented, with 47% of all activities being devoted to the development of this skill. These kinds of tasks could be reduced to make room for more tasks related to the development of diagrammatic and problem solving skills.

### 4.5.2 Depth

**Table 1 in Annexure B** indicates the degree of cognitive complexity (depth) required for each topic in the NCS and the CAPS. Codes representing content at the introductory level (1) to content at a high level of abstraction (4) were used to categorise the cognitive complexity.

The evaluation team interpreted the codes as follows:

**Level 1:** Introductory level content; superficial; mainly definitions and descriptions

**Level 2:** Definitions and descriptions plus some detail provided; involving simple relationships between concepts, and simple numerical calculations

**Level 3:** Detailed indications of concepts/topics; requires understanding of relationships between concepts; involving complex computations and interpretations

**Level 4:** High level of abstraction; topic required to be dealt with in a conceptually challenging way; requires complex understanding of relationships between concepts; requiring very demanding mathematical computations and problem solving

Table 34 below presents a summary of the content depth at each of these levels per grade and across the whole phase. The table also includes the total depth score which is the average depth of all of the topics covered in the curriculum.

**Table 34: Depth of topics per grade**

| Percentage of topics at each level | NCS | | | | | CAPS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gr 10 | Gr 11 | Gr 12 | Matric Exam | FET Phase | Gr 10 | Gr 11 | Gr 12 | Matric Exam | FET Phase |
| Level 1 | 7 | 0 | 2 | 2 | 3 | 4 | 3 | 0 | 0 | 3 |
| Level 2 | 35 | 21 | 17 | 24 | 26 | 35 | 30 | 25 | 27 | 31 |
| Level 3 | 41 | 49 | 52 | 64 | 52 | 48 | 49 | 63 | 62 | 52 |
| Level 4 | 17 | 30 | 29 | 11 | 19 | 13 | 19 | 13 | 12 | 15 |
| **Total depth score** | **2,70** | **3,09** | **3,08** | **2,84** | **2,88** | **2,69** | **2,84** | **2,88** | **2,85** | **2,79** |

Figure 10 below represents this information in graphical form.

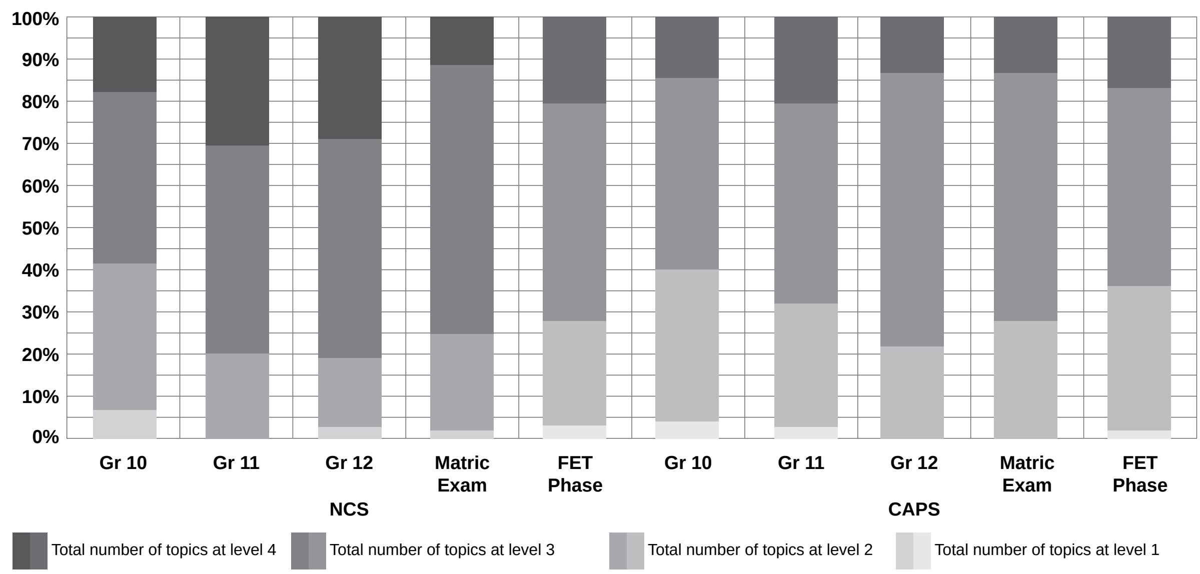


**Figure 10: Depth of topics per grade and phase**

The total depth scores for the different grades and for the whole FET Phase are represented for the NCS and the CAPS in Figure 11 below:

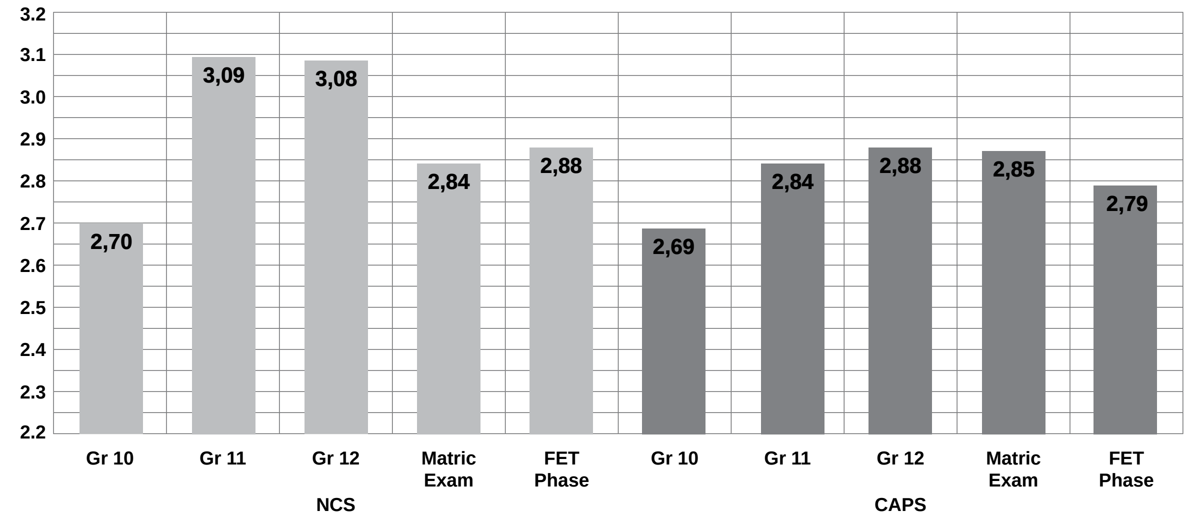


**Figure 11: Total depth score per grade and phase**

The following points are noted from this analysis of the content depth:

- For the **NCS** the depth of Grade 11 content is significantly high in comparison with the Grade 10 content. Both Grades 11 and 12 contain a high percentage of content at level 4 difficulty (30% and 29% respectively). This has been reduced in the caps to 19% (Grade 11) and 13% (Grade 12).

- For the CAPS, Figure 11 shows that there is a clear increase in the depth score across the three grades of the FET, allowing for conceptual development in learners from one grade to the next. In this sense the CAPS is an improvement over the NCS, where conceptual development is not as clearly apparent across the grades.

- The depth score for the **matric examination** content is remarkably similar across the NCS and CAPS curricula (2,84 in NCS and 2,85 in CAPS). What may have an impact on learner performance in the first few years of the CAPS Grade 12 examination is the inclusion of topics which have not been examined in the NSC from 2008 to 2013 (e.g. '*Newton's laws*', and '*Acids and bases*'). The unfamiliarity of these concepts is likely to mean that they will not be well taught in the first few years.

- Across the **whole FET Phase**, there has been a slight reduction in the overall depth of the CAPS physical science compared with the NCS, from 2,88 to 2,79. One can deduce that the conceptual demand of the CAPS is slightly lower than that of the NCS. Of course, the conceptual demand of a course is largely determined by the assessment, which is not incorporated in this phase of this evaluation/research study. This will be visited in a later research project.

### 4.5.3 Specification of topics

The curriculum specification, or degree to which knowledge is broken down for stipulation, was considered for the NCS and the CAPS. Coding was used to make a judgement of each curriculum, and examples were provided as justification for the coding[18].

| Table 35: Degree of specification of topics | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Degree of specification (High/medium/low)** | Low | High |
| **Example 1** | 'Types of reaction: acid-base and redox reactions' (Doc 1.1, p 47) | **Content, concepts & skills:**<br>• Determine the oxidation number from a chemical formula and electronegativities<br>• Identify a reduction- oxidation reaction and apply the correct terminology to describe all the processes<br>• Describe oxidation-reduction reactions as involving electron transfer<br>• Describe oxidation -reduction reactions as always involving changes in oxidation number<br>• Balance redox reaction equations by using oxidation numbers via the ion-electron method'<br>**Teaching guidelines:**<br>• Link redox reactions to oxidation numbers. In this section, care must be taken to emphasise the relationship between the symbolic (chemical reaction equations) and the macroscopic (what you see with your eyes) and sub-microscopic (on molecular level) representations of the reactions.(Doc 2.1, p 93) |
| **Example 2** | 'Kinetic energy' (Doc 1.1, p 38) | **Content, concepts & skills:**<br>• Define kinetic energy as the energy an object possess as a result of its motion<br>• Determine the kinetic energy of an object using $E_K = ½mv^2$<br>(Doc 2.1, p 58)<br>**Teaching guidelines:**<br>• Introduce kinetic energy as the energy an object has because of its motion. The same notation used for kinetic and potential energy in Physics, will also be used for those concepts in Chemistry.'<br>(Doc 2.1, p 58) |

18 **High:** High specification - extremely clear subject-specific specification: very little chance for multiple interpretations
**Medium:** Medium specification - moderately clear subject-specific specifications, some generic statements /skills or some topics underspecified
**Low:** Low specification - not clear subject-specific specification, minimal guidance provided for users and allows for multiple interpretations

The CAPS document has a much greater level of specification of content than the NCS. This is illustrated in the comparative examples given in Table 35. The more loose and open-ended structure of the NCS was intended to allow the teacher a high degree of creativity and flexibility. However, this approach relies on a body of teachers who are confident in their subject knowledge, and are able to adapt to the varying needs of learners. In reality the under-specification in the NCS led to a great deal of confusion and inconsistency in how the curriculum was implemented, and increased the divide between well-resourced and under-performing schools. The greater level of specification in the CAPS is helpful for guiding teachers who do not have a strong knowledge base or teaching expertise. Since most South African teachers are not confident in their subject knowledge (Taylor, 2008), this is an important characteristic of the CAPS.

## 4.6 COMMENTS ON CONTENT / SKILL COVERAGE

The conclusions of evaluation team are that the **overall breadth and depth** of content stipulated in the CAPS is appropriate across the whole FET Phase. Because of the high level of specificity of the content, teaching and learning guidelines in the CAPS, the evaluation team concluded that **clear, succinct, unambiguous and measurable** statements of learning are clearly present in the CAPS, by contrast with the more loosely specified NCS.

The reduction in the Chemical Systems component of Chemistry from the NCS to the CAPS has strengthened the **discipline-based** nature of the subject, since one can pay attention to the more fundamental Chemistry concepts and skills. However, the Matter and Materials section in the CAPS tends to weaken discipline boundaries between Physics and Chemistry, since it contains both Chemistry and Physics topics, and it is hence unclear to learners which discipline a particular topic relates to.

Although the CAPS is a more traditional curriculum than the NCS, which incorporates a range of **modern** technological features, these are beyond the scope of school-level learners, and make the NCS unwieldy and inaccessible. These topics were never actually taught in practice, as they were deemed non-examinable due to the difficulty and abstract nature of the underlying concepts.

Although the evaluation team's findings on the overall breadth, depth and presentation of the content in the Physical Science CAPS document (Doc 2.1) are positive, it is felt that the curriculum could be greatly improved by attention being given to the following issues:

- Undue repetition of content within and across the grades should be avoided. In particular, molar and stoichiometric calculations are stipulated in both Grade 10 (p 52) and Grade 11 (p 82), and progression in these concepts from one year to the next is not made sufficiently clear in the teaching guidelines. It is recommended that these topics be either removed from Grade 10, or taught at a more introductory, qualitative level. Providing example problems in the Grade 10 teaching guidelines would give a clear indication of the level of depth to which teachers should go.

- '*Electromagnetic radiation*' has been moved from Grade 12 in the NCS to Grade 10 in the CAPS (pp 29-31). This topic relies on a foundational understanding of electric and magnetic fields, which are not covered in the Grade 10 curriculum. It is recommended that this topic be moved out of Grade 10, and returned to Grade 12 where it fits with the conceptual progression of learners.
- In Grade 11 (p 95), increasing the number of options for mining industries is not helpful when these are all indicated as optional, since it creates potential confusion for assessment.
- The uncontextualized section '*Skills for practical investigations*' in Grade 12 seems inappropriate, as it is assumed that these skills are learned during the course of the practical work throughout the phase. It is inappropriate to place these skills in Grade 12 when they have been required in Grades 10 and 11. It would be more appropriate to allow time for general scientific skills at the start of Grade 10.
- Titration calculations are inappropriately mentioned under the topic of stoichiometry (Doc 2.1, p 82) where they are not required. In addition, on page 92 it is stated that titration calculations should be left to Grade 12. In Grade 12 this topic is appropriately dealt with in Doc 2.1, pp 127-128 under '*Acids and bases*'. It is recommended that any mention of titrations be removed from Grade 11 to avoid confusion and unnecessary repetition.
- In Grade 12 (Doc 2.1 p 138) under chemical systems the instruction is for one topic to be selected, or one topic to be covered each week for 3 or 4 weeks, however only one topic is provided from which to choose (the fertilizer industry). It is recommended that no options be allowed for here, and that for ease of assessment only the fertilizer industry be covered. This topic covers the range of necessary skills and application to a real life industry.
- There is a contradiction on p 49 (Doc 2.1), where the teaching notes suggest a superficial coverage of ion formation, but the content that is outlined is deeper than a superficial level. It is recommended that this be kept superficial at the Grade 10 level since it is dealt with thoroughly in Grade 11 (pp 67 - 74).
- Some pages in the CAPS document have no direct reference to the particular grade or term. A simple header on each page would help one to find one's way around the document with much more ease.
- On pp 127-128 (Doc 2.1), four experiments are included under the heading '*Prescribed experiment for formal assessment*', where only one of these is actually required. This will be very confusing to teachers. It is recommended that a simple acid-base reaction be used for titrations, for example, sodium hydroxide with hydrochloric acid, with phenolphthalein as the indicator, rather than the more complicated reactions provided on pages 127 and 128. It is also recommended that a uniform standard solution and unknown solution be provided to the learners to facilitate clear assessment of the experiment.

- Removal of '*Electric potential and electrical potential difference*' in the CAPS (which is in the NCS) is detrimental, since these concepts are required for a conceptual understanding of the electrical potential difference across circuit elements. It is recommended that these concepts be returned to the Grade 11 curriculum.
- In the Grade 11'*Waves, sound and light section*', the recommended experiment for formal assessment requires learners to find the critical angle of a rectangular clear block (Doc 2.1, p 77). This is very difficult to measure using a rectangular block. It is recommended that an alternative suggestion be made to use a semi-circular block.

### Inaccuracies and Incomplete Editing of the CAPS document

A number of errors and inconsistencies were found in the CAPS document (Doc 2.1). The list below is a list of examples. The document urgently requires a complete and thorough edit to avoid confusion by users of the document.

- In organic chemistry, there are inconsistencies in the organic compounds that are studied – those stipulated on pp 104 - 105 (Doc 2.1) contradict those stipulated on p 106, where dimethyl ether is introduced for the first time, in contradiction with the earlier list.
- In Grade 10 (Doc 2.1, p 38) the electric field and gravitational field are mentioned as analogies before they have been covered as topics.
- On p 53 the '*force vector*' is incorrectly referred to as the '*force factor*'.
- The document has missing information in numerous places. For example, on p 106 (Doc 2.1), under '*Practical activities*', there is a heading with nothing underneath it.
- On pp 110 – 112 (Doc 2.1), information is misplaced under '*Practical activities*' which should rather be under teaching guidelines.
- On p 51 (Doc 2.1), there is an experiment given, and no description of resource material is provided.
- On p 57, there is an incorrect symbol under the guidelines for the teacher column, where the number **20m<<s**$^{-1}$ should be replaced with **20 m.s**$^{-1}$
- There are contradictions in the amount of time allocated to teaching topics. For example, organic chemistry (Grade 12) is allocated 16 hours in the overview of topics (Doc 2.1, p 10), in the content outline the total number of hours is indicated as 12 hours (Doc 2.1, p 104), but if one adds the actual number of hours given per sub-topic, these come to 15 hours (Doc 2.1, pp 104 - 116).
- The document contains spelling errors, for example '*sstated*' (Doc 2.1, p 52).

## 4.7 CURRICULUM WEIGHTING AND EMPHASIS

### 4.7.1 Curriculum emphasis within the phase (Subject time allocation)

The emphasis of the whole FET Phase was ascertained by considering the number of hours allocated to physical science as a percentage of the total teaching time. These times were determined for the **NCS** under '*Time allocation for learning programmes*' (Doc 1.6, p 21) and '*Time allocation and weighting*' (Doc 1.2, p 14). For the **CAPS**, this information was found under '*Time allocation*' (Doc 2.1, p 7).

| Table 36: Subject time allocation | | |
|---|---|---|
| | **NCS** | **CAPS** |
| Total classroom time allocated for Physical Science in the phase | 4,5 of 29,5 hours/week according to Doc 1.6<br>4 of 27,5 hours/week according to Doc 1.2 | 4 of 27,5 hours/week |
| % of total classroom time allocated for all subjects in the phase | 15,3% (14,5%)<br>Doc 1.6 (Doc 1.2) | 14,5% |

In the NCS the time allocation for the subject is given in the NCS Overview Document (Doc 1.6, p 21). No mention of the time for the subject is mentioned in the actual Physical Science curriculum document (Doc 1.1). This information provided in the NCS Overview Document does not tally with the reality, where, according to team members who work in the field, the timing for the week is in actual fact 27,5 hours, as opposed to the 29,5 hours in the document. In addition, the time allocated to Physical Science learning at the FET Phase is 4 hours per week according to the Learning Program Guidelines document (Doc 1.2, p 14), not the 4,5 hours stipulated in the Overview Document (Doc 1.6). Consequently, in reality there is **no shift** in the time allocation or emphasis on the subject from the NCS to the CAPS.

### 4.7.2 Curriculum emphasis within the subject (Topic Weighting)

The emphasis of the physical science subject was ascertained by considering the number of hours allocated to each knowledge area as a percentage of the total time allocated to the subject. These times were determined for the **NCS** under '*Introduction to physical sciences*' (Doc 1.1, p 11). For the **CAPS**, this information was found under '*Overview of topics*' (Doc 2.1, pp 10 - 11), where the total time allocated to each topic was calculated as a percentage of the total time stipulated for all of the topics across the whole FET Phase.

| Table 37: Weighting per topic/emphasis within the subject | | |
|---|---|---|
| **Central topic** | **NCS** | **CAPS** |
| Mechanics | 12,5% | 25,3% |
| Waves, Sound & Light | 12,5% | 10,4% |
| Electricity & Magnetism | 12,5% | 13,7% |
| Matter & Materials | 25% | 20,2% |
| Chemical Systems | 18,75% | 6,5% |
| Chemical Change | 18,75% | 22,6% |
| Grade 12 skills for practical investigations | 0% | 1,2% |

Table 37 shows that the emphasis of the Physical Science curriculum has shifted dramatically from the NCS to the CAPS. In particular, the emphasis on '*Chemical Systems*' has reduced from 18,75% to 6,5%. Since this section is not strictly Chemistry-related, but contains content related to a range of other disciplines, such as soil and rock science and mineralogy, the reduction in this knowledge area has in fact strengthened the disciplinary nature of the CAPS. In addition, much of the specifically chemistry-related content which is included in this section in the NCS has been incorporated into other content areas, for example the topic '*Ions in aqueous solution*' has moved to the '*Chemical change*' section (Doc 2.1, p 46).

The knowledge area '*Mechanics*' is given a greater emphasis in the CAPS (25,3% compared with 12,5% in the NCS). This change is a good one, since '*Mechanics*' incorporates a range of foundational concepts and skills.

## 4.8 CURRICULUM PACING

The pacing of a curriculum is the rate at which content is expected to be covered, in given time frames, over the course of a grade or phase. This was considered for the NCS and the CAPS.

In Table 38 below the degree of **specification** of the pacing for each of the curricula is indicated, after assessment using a set of codes[19].

In addition, the **level of the pacing** itself as it would be experienced by learners at the FET Phase is indicated in Table 11 using another set of codes[20].

19 **High:** Very clear and explicit stipulation - pacing is made very explicit through clearly stipulating what topics are to be covered in what time frame over the course of the grade
**Moderate:** There is a moderate/some degree of specification of pacing, providing broad parameters as to what should be covered over the course of the grade
**Low:** Pacing is left open to the discretion of the teacher and little or no indication is given of the rate at which content should be covered over the course of the grade beyond a specification of content per phase

20 **Fast:** The pace expected is too fast for learners at this level of development
**Moderate:** The pace is moderate, and is appropriate for learners at this level of development
**Slow:** The pace is too slow for learners at this level of development

| Table 38: Pacing | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Level of specification of pacing (High/moderate/low)** | Low | High |
| **Rationale/justification** | No time allocation | Fine-grained time allocations (at times stipulated in intervals of 0,25 hours) |
| **Level of pacing itself (Fast/moderate/slow)** | Difficult to comment although breadth would suggest fast pacing | Fast for Gr 10, moderate for Gr 11 and 12 |
| **Rationale/justification** | Pacing not specified | Gr 10 has great breadth and depth |

In the **NCS** the pacing is **not specified** at all. This is left entirely up to the teacher. In the **CAPS**, the pacing is clearly stipulated, down to minute detail such as 15 minute intervals in some places. This prescriptive pacing may assist some teachers with planning their teaching programs and completing the curriculum. However, the time allocations are often too brief for the amount of material that is required to be covered. This will result in superficial learning. The very tight time stipulations do not allow for any flexibility for the teacher to be able to respond to varying learner needs. In this sense the extent of the specification of pacing may be experienced as a 'straight-jacket' by many teachers.

The actual level of pacing itself cannot be assessed for the **NCS** due to the lack of specification. However, because the breadth of content stipulated in the curriculum is extremely high, it can be concluded that the overall pacing would be fast, and would lead to superficial learning. The level of pacing for the **CAPS** is considered to be fast for Grade 10, as a consequence of the great breadth of the content stipulated for this grade, and this is likely to lead to a superficial level of engagement with the content. The pacing in Grades 11 and 12 is considered moderate, and should allow sufficient time for a sound grasp of the material.

Three members of the physical science evaluation team who are experienced subject advisors scrutinised the pacing of each of the individual topics. The following specific issues were noted where pacing is unrealistic in the CAPS:

- Additional time is required for the following topics:
    - **Grade 10:** Revision of Grade 9 work (requires 2 additional hours); '*states of matter*' (requires one additional hour); '*Electrical circuits*' (requires 2 additional hours); quantitative aspects of '*Chemical change*' (requires 4 more hours); '*Vectors and scalars*' (requires 2 more hours); '*Instantaneous speed and velocity*' (requires 2 more hours); '*Transverse pulses*' could be reduced by 2 hours. Hence an additional 11 hours would be needed to cover the Grade 10 topics as they stand.
    - **Grade 11:** '*Vectors in 2 dimensions*' (requires 2 more hours); '*Atomic combinations*' (requires 2 more hours). This is an additional 4 hours in total.

- **Grade 12:** '*Vertical projectile motion*' (requires1 more hour); '*Acids and bases*' (needs 2 more hours); '*Electric circuits*' (requires 2 more hours); '*Doppler effect*' can be reduced by 2 hours; the time allocated to '*Polymers*' (4 hours) has not been included in the total time allocated for '*Organic molecules*'. This is an additional 7 hours in total.

In the CAPS there are **contradictions** in the amount of time allocated to teaching topics. For example, organic chemistry (Grade 12) is allocated 16 hours in the overview of topics (Doc 2.1, p 10); in the content outline the total number of hours is indicated as 12 hours (Doc 2.1, p 104), but if one adds the actual number of hours given per sub-topic these come to 15 hours (Doc 2.1, pp 104 - 116). This is likely to result in a great deal of confusion, particularly for teachers who follow the work schedule very closely.

## 4.9 CURRICULUM SEQUENCING AND PROGRESSION

### 4.9.1 Specification of sequence

The sequencing of a curriculum is the order in which topics are required to be taught. In Table 39 below, the degree of specification of the sequencing for each of the curricula is indicated using descriptors[21].

**Table 39: Specification of sequencing**

| | NCS | CAPS |
|---|---|---|
| **Level of specification (High/ moderate/low)** | Low | High |
| **Rationale/justification** | Sequencing is left to the teacher's discretion | Sequencing is highly stipulated throughout Doc 2.1 |

In the **NCS** the sequencing is **not specified** at all. This is left to the discretion of the teacher. In the **CAPS**, the sequencing is clearly stipulated, and because of the practice of common testing, teachers are required to follow the stipulated sequence of material in the curriculum.

The sequencing of topics in Grades 11 and 12 are regarded as appropriate by the evaluation team, as there are no issues with topics being covered before the necessary underlying concepts and skills have been developed. However, the sequencing of topics in Grade 10 raised a number of concerns. The sequencing of knowledge areas in Grade 10 is shown in Table 40 below.

21 **High:** Highly specified sequence - the order in which topics are to be taught is clearly specified and prescribed within and across grades
**Moderate:** Moderately specified sequence - there is a general suggested order in which topics are expected to be taught within and across grades, but allowance is made for some discretion on the part of the teacher
**Low:** Topics are presented to be taught in no particular order within and across grades, and sequence is at the discretion of the teacher

| Table 40: Gr 10 sequencing of content | |
|---|---|
| **Term number** | **Knowledge area** |
| **Term 1** | Matter & materials |
| | Waves, sound & light |
| **April vacation** | |
| **Term 2** | Matter & materials |
| | Chemical change |
| | Electricity & magnetism |
| **July vacation** | |
| **Term 3** | Chemical change |
| | Mechanics |
| **September vacation** | |
| **Term 4** | Mechanics |
| | Chemical systems |

This table illustrates the confusing way in which knowledge areas are sequenced in the Grade 10 CAPS, with a number of discontinuities. The following discontinuities are of particular concern:

- The knowledge area of '*Matter & Materials*' is split over Terms 1 and 2, with the '*Waves, Sound & Light*' knowledge area inserted between these. This will cause confusion to learners, and will require teachers to revise what has been covered previously. No time is allocated to this revision.

- In Term 2 '*Chemical Change*' is followed by '*Electricity & Magnetism*', and then resumed again in Term 3 where '*Stoichiometry*' is covered. This is again an interruption for learners in the sequence of learning. Again no time has been allocated to the revision of prior material in this knowledge area.

There is a great deal of overlap between the Grade 10 '*Quantitative Aspects of Chemical Change*' (Doc 2.1, p 50) with similar content covered in Grade 11 (Doc 2.1, p 82). This repetition is unnecessary, and these topics could be removed from the Grade 10 curriculum to ease the issue of content overload. This would release 8 hours of teaching time.

### 4.9.2 Indication of progression

Progression is evident when the content and skills in a course increase in cognitive demand within a given grade or level, and from one level to the next. The sequencing and pacing of material in the course therefore needs to be appropriately structured to allow for this development. The various curricula were considered in this light. Table 41 below describes the level of indication of progression in each curriculum within each grade and across grades in the FET Phase.

| Table 41: Indication of progression – within and across grades | | | |
|---|---|---|---|
| | | **NCS** | **CAPS** |
| **Within grades** | **Level of indication (Strong/moderate/weak none)** | None | Weak |
| | **Rationale/justification** | Sequencing of topics and learning activities were left up to the teacher | Sequencing of topics show no consideration for conceptual progression |
| **Across grades** | **Level of indication (Strong/moderate weak/ none)** | Moderate | Moderate |
| | **Rationale/justification** | Some topics at Gr 10 level are very complex e.g. graphs and equations of motion, and graphs of motion for pulses | Some topics at Gr 10 level are very complex e.g. electromagnetic radiation, and graphs and equations of motion |

In the **NCS**, it is not possible to comment on progression **within each grade**, since the sequencing of topics is left up to the teacher. In the **CAPS**, although the sequencing of topics is clearly indicated, there is no real evidence that this sequencing takes into account the progression in cognitive demand of the topics. In particular, the knowledge area of '*Chemical Systems*' is placed at the end of each grade, but this is most descriptive and least conceptually challenging of all of the knowledge areas.

It is suggested that a slight shift in progression in the CAPS Grade 10 content would be beneficial for a more coherent and developmental learning experience. For example, this can be done by moving the topic of '*Physical and Chemical Change*' so that it follows after '*Kinetic Theory*', but precedes the '*Structure of the Atom*'. This would allow for greater conceptual progression, since the '*Structure of the Atom*' is a more deep and detailed understanding of particles than is covered in '*Physical and Chemical Change*'. There is a very clear hierarchical development of concepts within the discipline of Chemistry, and in order for learners to develop solid foundations in the discipline, this conceptual progression needs to be more clearly reflected in the curriculum.

Progression would also be enhanced by not interrupting the Chemistry topics with Physics topics. We also suggest putting the '*Mechanics*' section of Physics at the start of the Grade 10 year, since it includes some foundational concepts.

In the **NCS**, there is evidence of progression in content **across the three grades**, with each of the same knowledge themes being covered in greater complexity in the higher grades (Doc 1.1, pp 38 - 49). In addition, there is clear evidence of progression in terms of skills, with the description of the ASs gaining in complexity over the three grades (Doc 1.1, pp 18 - 33). For example at the Grade 10 level, LO 1, AS 1 is described as *'Plan and conduct a scientific investigation to collect data systematically with regard to accuracy, reliability and the need to control one variable'* (Doc 1.1, p 18). At the Grade 12 level, this same AS is described as *'Design, plan and conduct a scientific inquiry to collect data systematically with regard to accuracy, reliability and the need to control variables'*.

(Doc 1.1, p 19). However, in the NCS the conceptual demand at Grade 10 is made too high with the inclusion of some very complex concepts, such as graphs and equations of motion, and graphs of motion for transverse pulses.

In the **CAPS**, there is indication of progression **across the three grades**, where the overall depth increases from one grade to the next. Some of the topics which have been incorporated at the Grade 10 level, however, are considered by the evaluation team to be too demanding for learners at this level of their development, for example electromagnetic radiation, and graphs and equations of motion.

## 4.10 SPECIFICATION OF PEDAGOGIC APPROACHES

The pedagogic approach of a curriculum is the way in which teaching and learning is intended to happen in the classroom. Table 42 below describes the pedagogic approach where this is able to be inferred from the curriculum documents.

The table also indicates the degree to which the curriculum in question offers subject-specific guidance regarding the preferred pedagogic approach to be adopted using the descriptors below[22].

**Table 42: Specified pedagogic approach**

| | NCS | CAPS |
|---|---|---|
| **Subject-specific pedagogic approach (Description)** | Learner-centred, constructivist, enquiry-based approach | Teacher-centred, content driven approach |
| **Level of indication (High/ moderate/low/none)** | Low – instruction is very general, not clearly subject-specific | High – clear teaching guidelines are given throughout the document |

In the **NCS**, the curriculum is underpinned by the broad principles of OBE, and it is expected that a learner-centred constructivist approach to knowledge development will be implemented. However, the guidelines given are very general, and are not described in a subject-specific way. As a result this approach would have been difficult to realise in practice. Although the NCS includes a learning program guidelines document (Doc 1.2), this is still too general to be useful for teachers who require support in knowing how to implement a constructivist approach in physical science classrooms. For example, under the column 'Assessment', the learning program guidelines document states *'any form of assessment as outlined in the subject assessment guideline including practical work'* in every block (Doc 1.2 throughout). Under the column referring to the Learning and Teaching Support Material (LTSM), the guidelines given state: *'Science equipment:*

[22] **High:** High specification - detailed guidance is given in the curriculum regarding the preferred subject-specific pedagogic approach
**Moderate:** Moderate specification - some guidance is given in the curriculum regarding the preferred subject-specific pedagogic approach
**Low:** Low specification - the preferred subject-specific pedagogic approach is mentioned in a few places but no details are provided
**None:** No specification - the curriculum provides no information or guidance regarding the subject-specific pedagogic approach

*any relevant equipment from the home; textbook; library books; newspaper articles; any other resources including the internet'* (Doc 1.2 throughout).

The **CAPS** includes very clear content and teacher guidelines which give a great deal of clarification for teachers to know exactly what and how to teach. The approach in the CAPS is, in general, more appropriate for learners and teachers than that in the NCS. The clear structure will help to support a more meaningful learning experience, particularly in contexts where teachers struggle to plan their own work schedules. The clear structure to the curriculum enables learners and management to keep teachers accountable for the work that should be covered. Common exams are also more realisable. In addition, the CAPS outlines the resources and materials that are required for each activity, enabling better planning by the school and education authorities.

The role of the teacher and learner has shifted dramatically from the NCS to the CAPS. Under the **NCS**, the teacher is considered to be a mediator of the learning process, and a guide for the learners' own enquiry process in the construction of his/her scientific knowledge. The learning process is considered to be a negotiation of meaning, and learners are encouraged to use their judgement in questioning knowledge claims and understanding the limitations and cultural biases of scientific theories. The teacher is given a great deal of freedom in selecting what and how to guide the learning process, and the learner is seen as an important role player in the construction of knowledge itself.

In the **CAPS**, the role of the teacher is to implement the curriculum meticulously as it is laid out in the document. Knowledge is presented as static and non-negotiable, and there is no encouragement to question the basis on which knowledge is constructed or negotiated. Teaching schedules and activities are tightly prescribed and the teacher is given no freedom of choice or flexibility to decide on pacing, sequencing, context or activities. The perceived ideal learner in the CAPS is one who is a recipient of knowledge in terms of the content. However, this is not presented as a passive role, since the curriculum does outline a wide range of activities including experiments, problem solving, projects, model building and report writing.

In the NCS (Doc 1.1, pp 4 - 5) there is half a page given to the description of the kind of learner envisaged, and a paragraph on the kind of teacher that is envisaged. An equivalent description does not exist in the CAPS document. The specific role of teachers and learners receives less attention in the CAPS, which suggests an unstated reversion to a traditional conception of these roles.

## 4.11 ASSESSMENT GUIDANCE

In Table 43, the number and types of assessment tasks specified in the curriculum are indicated. Examples are provided of the dominant types of assessment specified for the different curricula.

The table further indicates whether the assessment guidance given is general, subject-specific, both or neither. The degree of clarity of guidance regarding assessment is indicated using codes[23].

| Table 43: Assessment | | |
|---|---|---|
| | **NCS** | **CAPS** |
| **Number of assessment tasks specified** | 7 per grade | 7 per grade |
| **Types of assessment specified** | Experiments, investigations, projects, research tasks, control tests, examinations | Experiments, investigations, projects, research tasks, control tests, examinations |
| **Examples of dominant types of assessment specified** | Tests and Exams (85% of final mark) | Tests and Exams (85% of final mark) |
| **Specificity of assessment guidance (General/subject-specific/ both)** | Both | Both |
| **Clarity of assessment guidance (High/moderate/low)** | Low | High |

In **both** the NCS and the CAPS, similar numbers and types of tasks are recommended for formal assessment. These include experiments, investigations, projects, research tasks, control tests and examinations. Together these cover the range of skills required in a Physical Science course. However, when one considers the allocation of marks in the final assessment mark, by far the greatest weighting is given to controlled testing and examinations (which together contribute 85% of the final mark). These forms of assessment test a particular range of skills, but are unable to assess leaners' experimental and reporting skills, as well as any form of open-ended investigation. Hence the skills that are indicated as important by the assessment practices in the NCS and the CAPS are those related to test and examination performance.

A concern raised for the assessment in the CAPS is that, for the mark allocation for Grades 10, 11 and 12 examinations (Doc 2.1, pp 148 - 149), the total marks for each examination paper is identical for all of these grades (150 marks), but for Grade 10 only 2 hours is allowed for the duration of each examination paper, whereas for Grades 11 and 12 the duration is 3 hours. This variation in mark-per-minute ratio is confusing for learners, who become accustomed to a certain pace of examination response. It is suggested that the total marks for the Grade 10 examination be reduced to match the 2 hour time allocation (ie 100 marks), or that the amount of time for each Grade 10 examination paper be increased to 3 hours.

23 **High:** High degree of clarity - assessment information is detailed, specific, clear, and comprehensive, and is not likely to result in differing interpretations
**Moderate:** There is a moderate degree of information regarding assessment that is generally clear
**Low:** There are broad statements about assessment that lack clarity and allow for multiple interpretations
**None:** There is no guidance provided for assessment

The CAPS document is unclear in the description of the Grade 10 informal assessment, where the document outlines 5 informal assessment tasks where only 4 are required per year. The document appears to be missing an 'OR' in the Grade 10 Term 4 informal assessment (Doc 2.1, p 12).

For all of the grades, a choice is offered between a recommended Physics and a Chemistry informal assessment activity in each term. In practice, it is therefore possible to only cover Physics activities, and no Chemistry ones, or vice versa. This could potentially result in a skewed development of skills. It is recommended that a minimum number of Physics and Chemistry related tasks be required in each grade.

## 4.12 CURRICULUM INTEGRATION

### 4.12.1 Integration between subjects

The extent of the integration between subjects in the NCS and the CAPS is indicated in Table 44 below, using a set of codes[24].

**Table 44: Integration between subjects**

| | NCS | CAPS |
|---|---|---|
| **Level of integration (High/ moderate/low)** | Low | Low |
| **Example 1** | *'The integration of knowledge and skills across subjects and terrains of practice is crucial for achieving applied competence'* (Doc 1.1, p 3) | 'Recall Theorem of Pythagoras' (Doc 2.1, p 61) |
| **Example 2** | No other example found | *'Science applies mathematics to investigate questions, solve problems, and communicate findings'* (Doc 2.1, p 154) |

Physical Science is a subject that leans strongly on mathematical underpinnings, and the integration with skills and techniques learned in Mathematics should be made explicit to facilitate transfer of these skills into Physical Science problem solving contexts. Physical Science also has many potential links with other disciplines, such as Geography (navigation, the atmosphere, lithosphere and hydrosphere) and Life Sciences (chemistry in living organisms).

In the **NCS**, reference is made to the importance of integration with other disciplines through the statement, *'The integration of knowledge and skills across subjects and terrains of practice is crucial for achieving applied competence'* (Doc 1.1, p 3). However,

23 **High:** Frequent and explicit references are made to integration with other subjects in the curriculum
**Moderate:** In a few places reference is made to other subjects or connection to topics in other subjects is made
**Low:** The subject is very separate from other subjects in the curriculum and there is very little or no referencing of other subjects

no explicit guidelines or examples are provided to demonstrate how these links can be made. Although various topics which lend themselves to integration are covered in the '*Chemical Systems*' section, such as the atmosphere, lithosphere and hydrosphere, no explicit reference to related subjects such as Geography or Life Sciences are made in the curriculum.

In the **CAPS**, there is very little evidence of an explicit mention of integration with other subjects. The only examples that were found in the document are *'Recall Theorem of Pythagoras'* (Doc 2.1, p 61) under the Grade 11 topic of '*Vectors in 2 Dimensions*', and *'Science applies mathematics to investigate questions, solve problems, and communicate findings'* (Doc 2.1, p 154) under the Grade 10 section '*Skills for Physical Sciences*'.

### 4.12.2 Integration with the everyday world and knowledge of learners

Table 45 below indicates the level of integration between the formal subject knowledge in Physical Science in the NCS and the CAPS and the everyday (general) knowledge of learners at this stage of their development and in this context using a set of codes[25].

**Table 45:Integration between subject and everyday knowledge**

| | NCS | CAPS |
|---|---|---|
| **Level of integration (High/moderate/low)** | High | Moderate |
| Example 1 | Reference to weather systems (Doc 1.1, p 50) | The chemistry of hard water (Doc 2.1, p 46) |
| Example 2 | Reference to the eyes of humans and animals (Doc 1.1, p 51) | 'Water bags on the outside of your car or camel' (Doc 2.1, p 74) |

In the **NCS**, integration is supported by LO 3 ('*The nature of science and its relationship to technology, society and the environment*'), where teachers are encouraged to use a range of everyday contexts, with suggestions made, for example reference to weather systems (Doc 1.1, p 50), to the physics of sight in humans and animals (Doc 1.1, p 51), and chemistry in the home (Doc 1.1, pp 52 - 53).

In the **CAPS**, integration with everyday knowledge is infrequent, and is mainly mentioned in the Teacher Guidelines, making this less important than if it was mentioned as part of the content outline. Some examples are useful, such as the chemistry of hard water (Doc 2.1, p 46), the analogy of a lawnmower moving from short to long grass (Doc 2.1, p 77), the environmental impact of mining (Doc 2.1, p 97), hazardous and corrosive household substances (Doc 2.1, p 127) and the application of acids and bases to hair straightening (Doc 2.1, p 128). Some examples are not very helpful, such as *'water bags on the outside*

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23 **High:** Learners' everyday world and knowledge, the world of work and communities are constantly referenced and form part of the knowledge specified in the curriculum
**Moderate:** Learners' everyday world and knowledge, the world of work and of learners' communities are referenced in a few places in the curriculum
**Low:** The curriculum emphasises subject-specific knowledge, and there are no or almost no references to the everyday knowledge of learners and their communities or the world of work

*of your car or camel'* (Doc 2.1, p 74), and *'legends and folklores about animal behaviour related to natural disasters'* (Doc 2.1, p 31).

## 4.13 CURRICULUM OVERVIEW

### 4.13.1 Curriculum coherence

Curriculum coherence refers to the extent to which a curriculum reflects a logic (often inherent in the nature of the discipline itself) in the organisation of topics, where the key ideas of the subject and their development over time, is evident.

The **NCS** is coherent in its design according to the principles of OBE. The curriculum is structured around the LO and ASs, and the organisation of the content is loosely structured, allowing for teachers to interpret this in a way that best enhances the learning program that they design. Although this is extremely unlikely to be realised in practice in a country like South Africa, where the majority of teachers lacks a solid foundation in terms of subject knowledge and teaching expertise, there is still a clear coherence in the overall value-base, intention and structure of the curriculum.

Coherence is somewhat more difficult to trace through the **CAPS**. The absence of explicit guidance on the underpinning educational approach, and on the role of the teacher and learner, means that these have to be inferred from the way the curriculum is structured. The extremely prescriptive way in which content and activities are outlined implies that this curriculum is a reversion to a traditional teacher-centred, content-based syllabus. Some of the stated objectives are not well followed through in the actual content outline, for example the promotion of environmental awareness, the development of an understanding of the nature of science and its relationships to technology, society and the environment, the preparation of learners for employment and citizenship, and the importance of Indigenous Knowledge Systems (Doc 2.1, p 8). The CAPS claims to encourage '*an active and critical approach to learning, rather than rote and uncritical learning of given truths*' (Doc 2.1, p 4). Although the learning that is likely to result from the content outline will be active, due to the many practical activities and other tasks that have been set, a critical approach is less likely to be developed, since the content is presented in the form of given truths, and learners are not encouraged to evaluate or critique knowledge claims.

Where the CAPS does show coherence with its stated objectives is in the intention to develop *'high knowledge and high skills'* (Doc 2.1, p 4). Since many teachers in South Africa need clear guidance about what constitutes sound knowledge and skills in Physical Science, the prescriptive and structured outline of content and practical activities in the CAPS will enable this development to take place. In addition, scientific skills are more explicitly outlined in the CAPS than in the NCS, which will further contribute to the development of a high skill base.

### 4.13.2 Implications for South African context

As mentioned in the above paragraph, because of the general lack of a sound knowledge base in Physical Science teachers, the structured outline of content and activities in the CAPS is more likely to facilitate the development of scientific knowledge and skills than the more open, non-prescriptive approach of the NCS. The CAPS is therefore, on the whole, a better curriculum for the South African educational context.

However, the practical activities prescribed in the CAPS require specialised scientific equipment, for example '*Air-track with blower. Two trolleys, pulley, two photo gates, two retort stands, dual timer, metre-stick, black card, set of equal weights*' (Doc 2.1, p 100) and '*Mercury discharge lamp; photosensitive vacuum tube; set of light filters; circuit to produce retarding voltage across phototube; oscilloscope, ammeter*' (Doc 2.1, p 132). A report documenting the facilities in South African schools (Equal Education, 2012) indicates that only 1 231 out of 24 793 South African schools have stocked laboratories. Consequently, **fewer than 5% of South African schools will actually be able to implement the practical requirements of the CAPS**. It is recommended that, until more schools are equipped with stocked laboratories, alternative equipment and approaches to the practical activities be suggested in the CAPS document.

### 4.13.3 Assumptions regarding teacher expertise

Because the general level of under-preparedness of teachers in South Africa, the CAPS is more appropriate than the NCS for this context presently because of the greater level of structure and guidance provided in the CAPS. This will ensure more of an even delivery across different schools, and makes common testing more reliable.

Many teachers are unable to do practical experiments themselves, even where facilities are available, which points to the need for specialised in-service training of teachers on the use of practical equipment in teaching.

## 4.14 CONCLUDING REMARKS

The overall **breadth of the content** specified in the curriculum has been reduced from the NCS to the CAPS, from 135 to 116 sub-topics (if one only takes the examinable topics into account for the NCS). This reduction in breadth is a positive shift, since the NCS is a very content-laden curriculum. The breadth of the CAPS Grade 10 is greater than that of either Grade 11 or Grade 12, and is likely to lead to superficial learning.

The **skills** in the NCS are underspecified, as these are presented as ASs which are very generically stated. In the CAPS, the skills are much more explicit and well developed, as these are clearly contained in the content and teaching guidelines. Problem solving skills and graphical skills are under-represented in the teaching plans compared with written skills, and a more balanced representation would enhance the development of important scientific skills in learners.

The **depth** of content across the whole FET Phase is slightly lower for the CAPS than in the NCS. The depth of content in the matric exam is identical across the two curricula. It can hence be concluded that once teachers and learners have adjusted to the new topics in the CAPS curriculum, learners are not likely to find the content any more conceptually demanding than that in the NCS.

The greater level of **specification** in the CAPS than in the NCS is helpful for guiding teachers who do not have a strong knowledge base or teaching expertise. In addition, the CAPS gives very detailed teaching guidelines which will assist teachers in their lesson planning and delivery. This will ensure that learners from a range of contexts will have more even learning opportunities than is the case with the more loosely-specified NCS. However, the **practical activities** that are prescribed in the CAPS require specialised scientific equipment. This will result in fewer than 5% of schools being able to implement the practical requirements of the CAPS. In addition, the lack of flexibility in presentation of the CAPS will hamper teachers' ability to respond to the varying needs of learners.

In summary, the actual content covered in the CAPS does not differ significantly in breadth or depth from the content that is examinable in the NCS. What has changed dramatically in the CAPS is the underlying educational approach, which has shifted from the more idealistic and open-ended OBE to a traditional and prescriptive teacher-centred, content-based syllabus model. The implications of this shift are that teachers are offered much clearer guidance, but less flexibility and opportunity for creativity than in the NCS. Learners are given a more even educational experience across different contexts, but play less of a role in the construction and negotiation of their own knowledge development.

## 4.15 RECOMMENDATIONS

- Although the overall breadth and depth of the CAPS content is appropriate across the whole FET Phase, the breadth of content in the CAPS Grade 10, together with the depth of conceptual demand, is found in this evaluation to be too extensive. It is recommended that some topics be removed from the Grade 10 curriculum (particularly where there is overlap with Grade 11 and 12 topics) and studied only in the latter 2 grades.
- In particular the following topics should receive attention:
    - '*Molar and stoichiometric calculations*' are stipulated in both Grade 10 (Doc 2.1, p 52) and Grade 11 (Doc 2.1, p 82), and progression in these concepts from one

year to the next is not made sufficiently clear in the teaching guidelines. It is recommended that these topics be either removed from Grade 10, or taught at a more introductory, qualitative level. Providing example problems in the Grade 10 teaching guidelines would give a clear indication of the level of depth to which teachers should go.

  - '*Electromagnetic radiation*' has been moved from Grade 12 in the NCS to Grade 10 in the CAPS (Doc 2.1, p 29-31). This topic relies on a foundational understanding of electric and magnetic fields, which have not yet been covered in the Grade 10 curriculum. It is recommended that this topic be moved out of Grade 10, and returned to Grade 12 where it fits with the conceptual progression of learners.

- The sequencing of content topics at Grade 10 level is considered to be problematic, as the interruption of some of the knowledge areas by unrelated areas will cause confusion and will interrupt the conceptual development in learners. It is recommended that the sequencing of Grade 10 topics be revisited.

- A slight shift in progression in Grade 10 content would be beneficial for a more coherent and developmental learning experience. This can be done by moving the topic of '*Physical and Chemical Change*' so that it follows after '*Kinetic Theory*', but precedes the '*Structure of the Atom*'. This would allow for greater conceptual progression, since the '*Structure of the Atom*' is a more deep and detailed understanding of particles than is covered in '*Physical and Chemical Change*'. There is a very clear hierarchical development of concepts within the discipline of chemistry, and in order for learners to develop solid foundations in the discipline, this conceptual progression needs to be more clearly reflected in the curriculum. Progression would also be enhanced by not interrupting the chemistry topics with physics topics. We also suggest putting the '*Mechanics*' section of Physics at the start of the Grade 10 year, since it includes some foundational concepts.

- It was found that problem solving skills are under-represented in the prescribed learning activities that are outlined in the CAPS teaching plans. It is recommended that the teaching guidelines could incorporate regular ideas and brief examples of specific problem solving activities related to the content to ensure that this important skill is well developed.

- '*Unit conversions*' are mentioned very seldom. It is recommended that problems and contexts involving unit conversions are more explicitly outlined in the teaching guidelines in the CAPS document.

- Diagrammatic skills, including representation of data in tabular and graphical form, are under-represented across the whole FET Phase. It is recommended that more explicit mention be made of graphical and tabular skills, and that these be incorporated into more of the activities and content descriptions.

- The skill of written response in the form of descriptions, discussions, explanations and reports is over-represented, with 47% of all activities being devoted to the development of this skill. These kinds of tasks could be reduced to make room for more tasks related to the development of diagrammatic and problem solving skills.

- The practical activities recommended in the CAPS require specialized scientific equipment, and many South African schools do not have functioning laboratories. It is therefore recommended that, until more schools are equipped with stocked laboratories, alternative equipment and approaches to the practical activities be suggested in the CAPS document.

- The total mark allocation (Doc 2.1, pp 148-149) for each examination paper is identical for Grades 10, 11 and 12 examinations (150 marks per paper), but for Grade 10 only 2 hours is allowed for the duration of each examination paper, whereas for Grades 11 and 12 the duration is 3 hours. It is suggested that the total marks for the Grade 10 examination be reduced to match the 2 hour time allocation (ie 100 marks), or that the amount of time for each Grade 10 examination paper be increased to 3 hours to allow for an even mark-per-minute ratio across all three grades of the FET Phase.

- Titration calculations are inappropriately mentioned under the topic of '*Stoichiometry*' (Doc 2.1, p 82) where they are not required. In addition, on page 92, it is stated that titration calculations should be left to Grade 12. In Grade 12 this topic is appropriately dealt with on p127-128 (Doc 2.1) under '*Acids and bases*'. It is recommended that any mention of titrations be removed from Grade 11 to avoid confusion and unnecessary repetition.

- For Grade 12 (Doc 2.1, p 138) under '*Chemical Systems*', the instruction is for one topic to be selected, or one topic to be covered each week for 3 or 4 weeks, however only one topic is provided from which to choose (the fertilizer industry). It is recommended that no options be allowed for here, and that for ease of assessment only the fertilizer industry be covered. This topic covers the range of necessary skills and application to a real life industry.

- There is a contradiction on p 49 (Doc 2.1), where the teaching notes suggest a superficial coverage of ion formation, but the content that is outlined is deeper than a superficial level. It is recommended that this be kept superficial at the Grade 10 level since it is dealt with thoroughly in Grade 11 (Doc 2.1, pp 67-74).

- Some pages have no reference to the particular grade or term. It is recommended that a simple but informative header be inserted on each page to help one to find one's way around the document with more ease.

- On pp 127-128 (Doc 2.1), four experiments are described under the heading '*Prescribed experiment for formal assessment*', where only one of these is actually required. This may be confusing to teachers. It is recommended that a simple acid-base reaction be used for titrations, for example sodium hydroxide with hydrochloric acid, with phenolphthalein as the indicator, rather than the more complicated reactions provided on pp 127-128 (Doc 2.1). It is further recommended that a uniform standard solution and unknown solution be provided to the learners to facilitate clear assessment of the experiment.

- Removal of '*Electric potential and electrical potential difference*' from the CAPS is detrimental (it is in the NCS), since these concepts are required for a conceptual understanding of '*Electrical potential difference*'. It is recommended that these concepts be returned to the Grade 11 curriculum.

- In the Grade 11 '*Waves, sound and light*' section, the recommended experiment for formal assessment requires learners to find the critical angle of a rectangular clear block (Doc 2.1, p 77). This is very difficult to measure using a rectangular block. It is recommended that an alternative suggestion be made to use a semi-circular block.

# 5 PHYSICAL SCIENCES: EXIT-LEVEL OUTCOMES FOR THE FET PHASE

In determining the exit-level outcomes for the FET Phase, the content topics and skills were treated separately. The teaching plans given on pp 98-142 of the CAPS document (Doc 2.1) were used in determining these outcomes. Table 46 below contains the content topics which are covered in the final Grade 12 examination, clustered under the broad content areas.

| **Table 46: Content topics examined at exit (Gr 12)** | |
|---|---|
| **Mechanics** | |
| **Motion in 1-D:** | Vertical projectile motion in 1D using words, diagrams, equations and graphs |
| **Force, momentum and impulse:** | Types of forces: weight, normal force, frictional force, applied, tension |
| | Newton's 1st law, Newton's 2nd law (including problems) |
| | Force diagrams, free body diagrams |
| | Newton's 3rd law |
| | Impulse |
| | Momentum: as vector, conservation, change in momentum in collisions, force = rate of change of momentum, elastic and inelastic collisions |
| | Contact and non-contact forces, fields |
| | Definition of gravitational acceleration, differentiate mass and weight, calculations with mass and weight |
| | Newton's Law of Universal gravitation |
| **Work, power and energy:** | Concepts of work, power and calculations |
| | Gravitational potential energy, Kinetic energy, Mechanical energy (KE + PE), conservation of mechanical energy |
| | Conservation of energy |
| | Work energy theorem |
| | Work done by force at an angle |
| **Waves, sound and light** | |
| **Doppler effect** | With sound and ultrasound |
| | With light – red shifts in the universe (evidence for expanding universe) |
| **Electricity and magnetism** | |
| **Electrostatics:** | Force between charges (Coulomb's law) |
| | Electric field around single charges and groups of charges, electric field between parallel plates |
| **Electric circuits:** | Closed circuit, electrical potential difference (voltage), current, resistance, principles and instruments of measurement of voltage (pd), current and resistance (advanced), relation between current, voltage and resistance (Ohm's law) |
| | Resistance, equivalent resistance, series and parallel networks |
| | Emf + internal resistance (quantitative) |
| | Energy transfer in electric circuits, electrical power (calculations) |
| **Electromagnetism:** | Magnetic field associated with current, current induced by changing magnetic field |
| **Electrodynamics:** | Electrical machines (generators, motors) |
| | Alternating current |

| Table 46: Content topics examined at exit (Gr 12) (continued) | |
|---|---|
| **Matter and materials** | |
| **Introduction to materials:** | Observing, describing, classifying and using materials |
| **Chemical bonding:** | Intermolecular forces vs intramolecular forces |
| **Optical phenomena and properties of materials:** | Emission and absorption spectra |
| | Photoelectric effect |
| **Organic molecules:** | Organic molecular structures – functional groups, saturated and unsaturated structures, isomers |
| | Systematic naming and formulae (up to 8 carbons): alkanes, alkenes, alkynes, alcohols, aldehydes, carboxylic acids, ketones |
| | Structure and function relationships of organic molecules |
| | Addition reactions |
| | Substitution and elimination reactions, with applications |
| **Organic macromolecules:** | Plastics and polymers – basic polymerization |
| **Chemical change** | |
| **Representing chemical change:** | Balanced chemical equations |
| **Quantitative aspects of chemical change:** | Stoichiometric calculations, molar volume of gases |
| | Types of reactions: redox reactions, oxidation numbers, oxidation and reduction |
| | Acids and Bases, Arrhenius, Bronsted-Lowry, pH (concept) |
| | Acids and Bases: Kw, Ka, Kb, pH calculations |
| **Rate and extent of reaction:** | Endothermic and exothermic reactions |
| | Energy changes in reactions, activation energy |
| | Rates of reaction and factors affecting rate, measuring rates of reactions |
| | Mechanism of reaction and of catalysis |
| | Chemical equilibrium and factors affecting equilibrium |
| | Equilibrium constant, application of equilibrium principles |
| **Electrochemical reactions:** | Electrolytic cells |
| | Galvanic cells |
| | Understanding of the processes and redox reactions taking place in cells, Standard electrode potentials, Writing equations representing oxidation and reduction half reactions and redox reactions |
| | Relation of current and potential to rate and equilibrium, electrolytic cells |
| **Chemical systems** | |
| **Chemical Industries** | The fertilizer industry (N, P, K) |

Table 47 below contains the skills which are covered in the final Grade 12 examination, clustered under the broad skill areas. The table also indicates the level of cognitive demand of each of these skills, categorised using the new Umalusi Physical Science taxonomy. A summary of this taxonomy is given in Table 3 in Annexure B.

| Table 47: Skills in recommended classroom activities | |
|---|---|
| | **Level of cognitive demand** |
| **Language and logic skills** | |
| Define | 1 |
| State laws / principles | 1 |
| Revise | 1 |
| Name | 1 |
| Reproduce | 1 |
| Read for comprehension | 2 |
| Write clear, reasoned responses to questions | 3 |
| Understand and use scientific terminology accurately | 2 |
| Write appropriately according to the scientific genre | 3 |
| Explain | 4 |
| Describe | 2 |
| Apply scientific laws/principles to various contexts | 3 |
| List | 1 |
| Characterise | 2 |
| Identify | 2 |
| Infer | 3 |
| Use analogies | 2 |
| Provide evidence of understanding and deduction | 4 |
| Translate / interpret between symbolic and textual representation | 3 |
| Verify / defend / argue | 4 |
| Compare / contrast / differentiate / analyse | 4 |
| Relate concepts | 2 |
| Perform logical / deductive reasoning | 3 |
| Write / draw conclusions based on given information or calculations | 3 |
| Verbal skills e.g. argue, debate, discuss, present | 4 |
| Listening skills e.g. follow verbal instructions, hear for meaning, re-express | 2 |
| **Mathematical skills** | |
| SI symbols and units, conversions, correct usage | 2 |
| Scientific notation | 2 |
| Basic numerical skills: fractions, ratios, rates, proportions, constants, percentages, mean, average | 2 |
| Advanced numerical skills: understand sign conventions, solve algebraic equations with multiple variables, simultaneous equations, change subject of the formula, proportional reasoning | 3 |
| Trigonometry: trigonometric ratios (sin, cos, tan), Pythagoras' theorem, resolve 2D vectors into components | 2 |
| **Problem solving skills** | |
| Interpret descriptive and diagrammatic scenarios into mathematical representations | 2 |

| Table 47: Skills in recommended classroom activities (continued) | |
|---|---|
| | Level of cognitive demand |
| Identify known and unknown variables | 2 |
| Select appropriate equation(s) | 2 |
| Perform simple calculations | 2 |
| Represent physical scenario using diagram | 3 |
| Solve multi-step calculations | 3 |
| Interpret results of calculations | 3 |
| Estimate magnitude of answer, reflect on answer | 3 |
| **Research Skills** | |
| Perform source-based research - literature/online/interview/survey, search for relevant information | 2 |
| Present the results of research - posters, reports, verbal | 3 |
| Conduct a survey | 2 |
| **Practical skills** | |
| Classify | 2 |
| Know and apply safe laboratory practice | 1 |
| Design and build a working device | 5 |
| Design experiment/investigation including controls | 3 |
| Formulate experimental hypotheses | 3 |
| Predict the outcome of an experiment | 4 |
| Make and record observations | 2 |
| Know and apply suitable precautions | 1 |
| Collect experimental data | 2 |
| Arrange, interpret and analyse data | 3 |
| Determine appropriate forms of representing data | 2 |
| Follow instructions to perform an experiment, using equipment correctly | 2 |
| Construct experimental setup from diagrams / descriptions e.g. electric circuit | 3 |
| Take readings from apparatus | 2 |
| Differentiate between accuracy and precision | 3 |
| Select appropriate tools / technology for the required data collection | 3 |
| Construct data tables and record measurements | 2 |
| Interpret and analyse tabular data | 3 |
| Determine sources of bias and experimental error | 3 |
| Suggest suitable experimental techniques | 3 |
| Recognise, analyse and evaluate alternative explanations for the same set of observations | 4 |
| Define qualitative vs quantitative analysis | 1 |
| Make estimates from readings | 3 |
| Draw conclusions | 3 |
| Write a practical report | 3 |

| Table 47: Skills in recommended classroom activities (continued) | |
|---|---|
| | Level of cognitive demand |
| Perform a titration | 2 |
| Prepare a standard solution and understand its significance | 2 |
| Use experiments to determine influencing factors on a system (e.g. change in reaction rates and equilibria) | 3 |
| **Graphical/diagrammatic skills** | |
| Determine and name correct axes, scales, units and title for a graph | 2 |
| Draw graph from data, including best fit curve, gradient, intercepts | 2 |
| Interpret and analyse graphs, and explain physical meaning of graph | 3 |
| Predict shape of graphs, and make simple sketches of graphs | 3 |
| Translate between different graphical representations of the same physical phenomena | 3 |
| Represent information in diagrammatic form e.g. heating curve, circuit diagrams, force diagrams, atomic diagrams | 2 |
| Models in science, e.g. build models using putty etc, to represent 3D visualisation | 3 |
| Illustrate sub-microscopic processes diagrammatically | 3 |
| **Scientific reasoning skills** | |
| Apply theoretical principles in everyday contexts | 4 |
| Demonstrate an understanding of underlying physical phenomena - translate between abstract / theoretical and real scenarios | 4 |
| Identify and represent all influences (e.g. forces) impacting on a system | 4 |
| Synthesise and communicate consequences (results) of all influences impacting on a system | 5 |
| Distil key information by extracting core components from text and diagrams. | 3 |
| Explain phenomena using diagrams | 3 |
| Use laws to explain phenomena | 4 |
| Explain the significance of a phenomenon | 4 |
| Use general representations, e.g. a formula for a family of molecules, different formulaic representations e.g. structural, condensed and molecular formulae | 2 |
| Use symbolic representations to describe sub-microscopic behaviour and relationships | 2 |
| Write and interpret formulae, IUPAC names, functional groups and chemical equations | 3 |
| Interpret between scientific terms/names and general names | 1 |
| Visualise molecular structures, shapes and representations (in 3D) | 4 |
| Given products, identify reactants and vice versa | 2 |
| Relate physical properties and functions with structural characteristics | 3 |
| Apply scientific phenomena in industrial and practical contexts | 3 |
| Identify the building blocks of a complex structure e.g. the monomer within a polymer | 2 |
| Identify the movement and conservation of energy | 2 |
| Use various notations for chemical reactions e.g. cell notation, half-reactions, net reactions, ionic equations | 2 |

| Table 47: Skills in recommended classroom activities (continued) | |
|---|---|
| | **Level of cognitive demand** |
| Interpret the structure of a table (including the periodic table) to determine trends, make predictions including periodic table | 3 |
| Integrate concepts from physical sciences with ecology, life sciences, the environment etc. | 4 |
| Evaluate the impact of science on the environment, society etc. | 4 |
| Explain using chemical reactions e.g. the production of fertilizer | 3 |
| **Level 1** | **10** |
| **Level 2** | **36** |
| **Level 3** | **38** |
| **Level 4** | **15** |
| **Level 5** | **2** |

### Omissions/Gaps

According to the Umalusi evaluation team, all of the key skills and content topics are adequately covered in the Grade 12 examinable curriculum (exit level). No obvious omissions were noted by the evaluation team.

### Weighting of Topics

The weighting of the topics is presented in Table 48 below, both in terms of time allocated in the teaching plans (pp 10 - 11, Doc 2.1), and in terms of examination weighting (derived from Table 11, p 150, Doc 2.1).

| Table 48: Time and examination weighting per topic | | |
|---|---|---|
| **Content Areas** | **FET Phase Time allocation (%)** | **CAPS Gr 12 Exam weighting (%)** |
| **Mechanics** | 27 | 21 |
| **Waves, Sound & Light** | 4 | 6 |
| **Electricity & Magnetism** | 16 | 18 |
| **Matter & Materials (Physics)** | 4 | 5 |
| **Matter & Materials (Chemistry)** | 16 | 16 |
| **Chemical Systems** | 4 | 6 |
| **Chemical Change** | 30 | 28 |

There is a good match between the amount of time allocated to the teaching of the examinable material and the mark weighting given in the final Grade 12 assessment for these content areas. The only topic where there is a notable discrepancy is mechanics, but since this topic is a challenging one it does require more teaching time.

The evaluation team considers the emphasis to be appropriate, since the more heavily weighted topics are those that are fundamental to future learning within the subject.

**Weighting of skills/competencies**

The evaluation team concluded that the curriculum covers all of the required skills and competencies that would be expected of a learner exiting the FET Phase. No key skills are overlooked.

The skills are reinforced through repetition within the context of the various content areas. In addition, the CAPS recommends that learners engage in problem solving activities on a daily basis (p 9 of the CAPS). One practical activity per term is the minimum requirement, as well as one informal test. This will ensure an on-going assessment of these skills.

**Weighting of cognitive levels**

The CAPS recommends that the daily problem solving activities that learners engage in should cover all cognitive levels (Doc 2.1, p 9). The prescribed weighting of the cognitive levels in the Grade 12 examination (according to the CAPS taxonomy on p 150, Doc 2.1) is given in Table 49 below:

| Table 49: Prescribed weighting of cognitive levels (Gr 12) (%) | | | | |
|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | Level 4 |
| Physics | 15 | 35 | 40 | 10 |
| Chemistry | 15 | 40 | 35 | 10 |

In order to estimate the weighting given to various cognitive skills in terms of the prescribed activities in the teaching plans, the list of outcomes that was gleaned from the Grade 12 curriculum (as listed in Table 47) was mapped against the cognitive levels provided in a modified Physical Sciences taxonomy that is regarded by the evaluation team to be appropriate for the needs of the subject (Table 3 in Annexure B). The pie chart below shows the emphasis in terms of these cognitive categories:

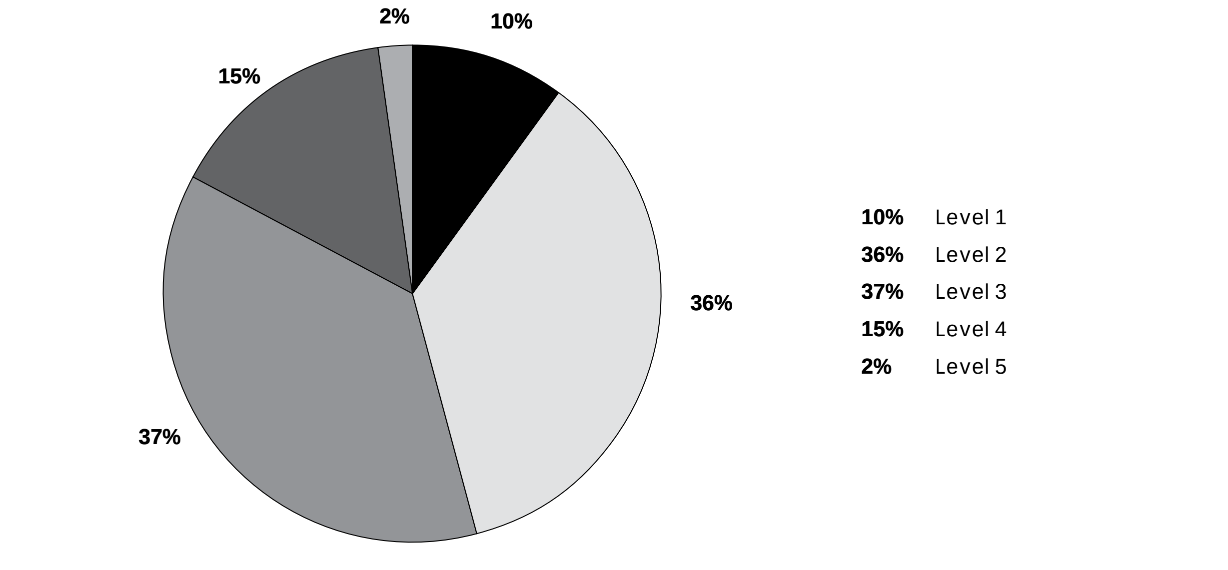


**Figure 12: Cognitive levels of exit-level skills**

It should be noted that this proportion of allocation of cognitive levels may vary, depending on the structure and standard of the actual assessment. However, there is a good match between the prescribed weighting of cognitive levels for the final Grade 12 assessment (Table 49 above) and the classroom-based activities that are recommended in the CAPS teaching plans (as illustrated in Figure 12 above).

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# ANNEXURE A: LIFE SCIENCES

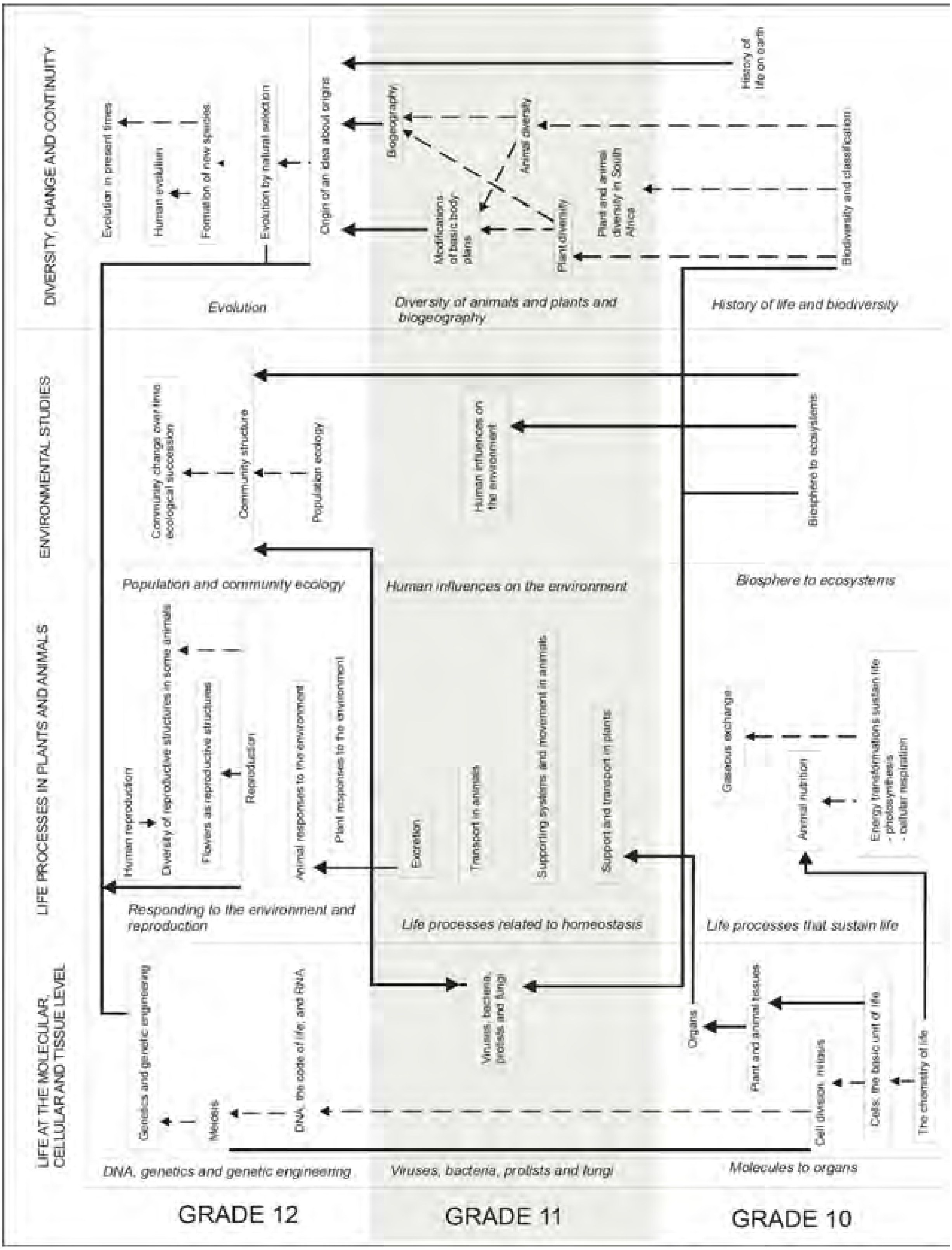


***Figure 1a - Conceptual progression map of the knowledge content in the NCS2 (Johnson et al., 2011)***

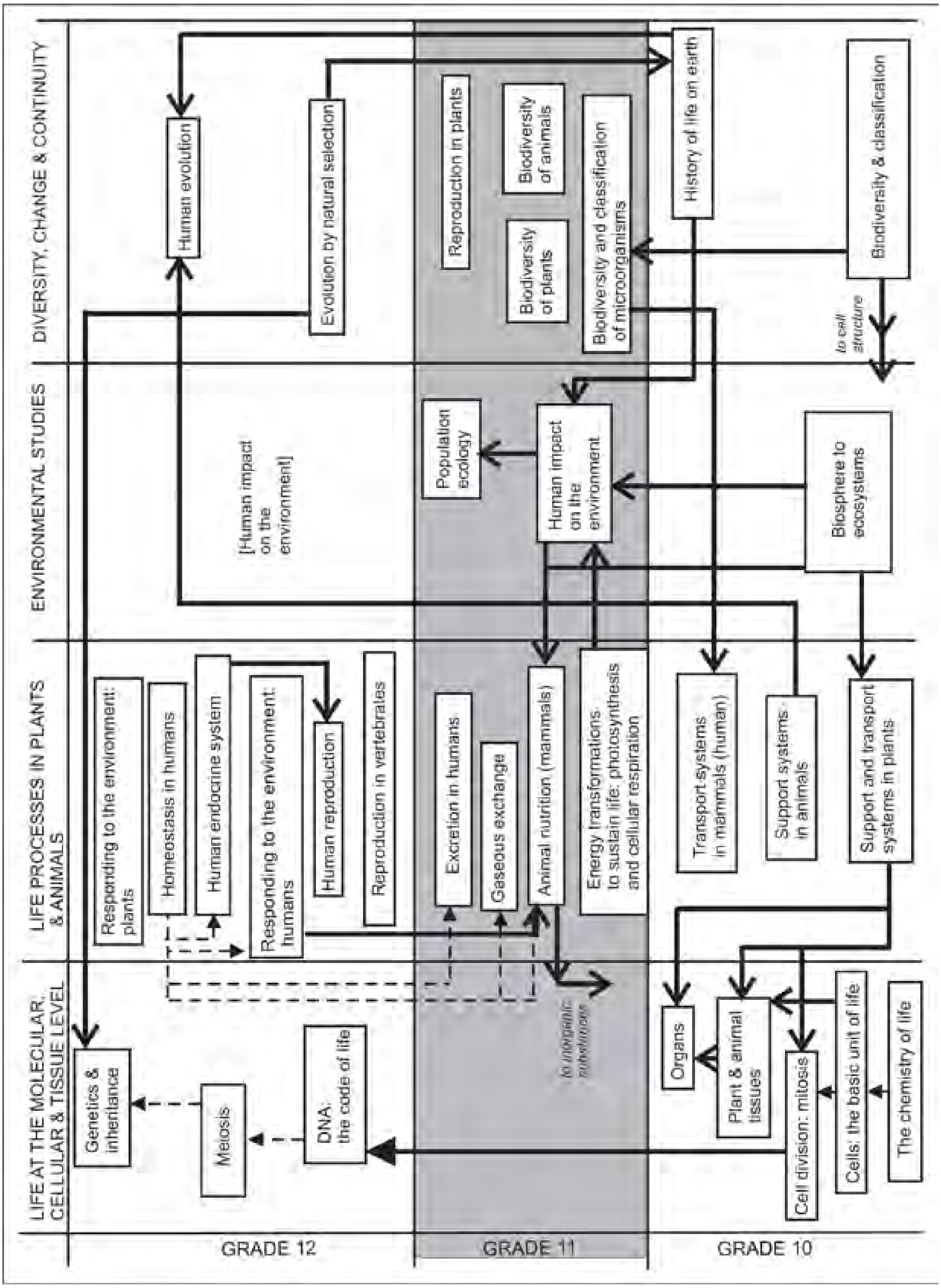


*Figure 1b - Conceptual progression map of the knowledge content in the CAPS (Johnson, Dempster and Hugo, in prep.)*

# ANNEXURE B: PHYSICAL SCIENCES

## TABLE 1: DETAILED CONTENT COVERAGE IN THE PHYSICAL SCIENCES

**Table 1** below indicates the content topics and sub-topics covered per grade in each curriculum, and the degree of cognitive complexity (depth) at which each topic is dealt with in the NCS and the CAPS. The following codes were used to categorise the cognitive complexity:

- **1:** Introductory level content; superficial; mainly definitions and descriptions
- **2:** Definitions and descriptions plus some detail provided; involving simple relationships between concepts, and simple numerical calculations
- **3:** Detailed indications of concepts/topics; requires understanding of relationships between concepts; involving complex computations and interpretations
- **4:** High level of abstraction; topic required to be dealt with in a conceptually challenging way; requires complex understanding of relationships between concepts; requiring very demanding mathematical computations and problem solving

Where a topic/sub-topic is not covered at all in a curriculum, the relevant blocks are shaded in blue.

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| **BASIC SCIENTIFIC SKILLS** | | | | | | | | |
| SI symbols and units, conversions | | | | | 2 | | | |
| Scientific notation | | | | | 2 | | | |
| Mathematical skills - fractions, ratios, rates, proportions, constants, trig | | | | | 2 | | | |
| Practical skills | | | | | | | 3 | |
| **MECHANICS** | | | | | | | | |
| **Vectors:** | | | | | | | | |
| Vectors in 1D: Vector diagrams, addition and subtraction of vectors | | | | | 3 | | | |
| Vectors in 2D: Vector diagrams, force diagrams, equilibrium of forces, components | | | | | | 3 | | |
| **Motion in 1-D:** | | | | | | | | |
| Position, displacement, distance, Speed, velocity, acceleration | 2 | | | | 2 | | | |
| Average velocity, instantaneous velocity | 3 | | | | 3 | | | |
| Description of 1D motion in words, equations (inlcuding problem solving) | 3 | | | | 3 | | | |
| Description of 1D motion in diagrams | 4 | | | | 4 | | | |
| Graphs of motions for position-time and velocity-time | 4 | | | | 4 | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| Graphs of acceleration-time | 4 | | | | 4 | | | |
| Frames of reference | 3 | | | | 3 | | | |
| Projectile motion in 1D | | | 4 | 4 | | | 4 | 4 |
| Momentum: as vector, conservation, change in momentum in collisions, force = rate of change of momentum, elastic and inelastic collisions | | 3 | | 3 | | | 3 | 3 |
| Identify torque, mechanical advantage | | 2 | | | | | | |
| Calculations with torque | | 3 | | | | | | |
| **Motion in 2D:** | | | | | | | | |
| Projectile motion represented in words, diagrams and graphs | | | 4 | | | | | |
| Conservation of momentum in 2D, elastic and inelastic collisions in 2D | | | 4 | | | | | |
| Frames of reference | | | 4 | | | | | |
| **Force, momentum and impulse:** | | | | | | | | |
| Types of forces: weight, normal force, frictional force, applied, tension | | 2 | | 2 | | 2 | | 2 |
| Newton's 1st law, Newton's 2nd law (including problems) | | 3 | | 3 | | 4 | | 4 |
| Force diagrams, free body diagrams | | 3 | | 3 | | 3 | | 3 |
| Frictional forces (static and kinetic) | | 3 | | | | 3 | | |
| Newton's 3rd law | | 2 | | 2 | | 2 | | 2 |
| Impulse | | 3 | | 3 | | | 3 | 3 |
| Contact and non-contact forces, fields | | 3 | | 3 | | 3 | | 3 |
| Definition of gravitational acceleration, differentiate mass and weight, calculations with mass and weight | 2 | | | | | 2 | | 2 |
| Newtons Law of Universal gravitation | | 3 | | | | 3 | | 3 |
| **Work, power and energy:** | | | | | | | | |
| Concepts of work, power and calculations | | | 3 | 3 | | | 3 | 3 |
| Gravitational potential energy, Kinetic energy, Mechanical energy (KE + PE), conservation of mechanical energy | 3 | | | 3 | 3 | | | 3 |
| Conservation of energy | | | 3 | 3 | | | 3 | 3 |
| Work energy theorem | | | 4 | 4 | | | 4 | 4 |
| Work done by force at an angle | | | 3 | 3 | | | 3 | 3 |
| **WAVES, SOUND AND LIGHT** | | | | | | | | |
| **Transverse pulses on a string or spring:** | | | | | | | | |
| Pulse length, amplitude, speed, | 2 | | | | 2 | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| Relation of pulse speed to medium | 3 | | | | | | | |
| Graphs of particle position, displacement, velocity, acceleration (Pulses) | 4 | | | | | | | |
| Superposition of pulses | 2 | | | | 2 | | | |
| Transmission and reflection at a boundary, Reflection from a fixed end and a free end, superposition of pulses | 3 | | | | | | | |
| **Transverse waves:** | | | | | | | | |
| Wavelength, frequency, amplitude, period, wave speed in different media | 2 | | | | 2 | | | |
| Calculations with the wave equation | 3 | | | | 3 | | | |
| Particle position, displacement, velocity, acceleration (with graphs) | 4 | | | | | | | |
| Standing waves with different boundary conditions (free and fixed end) as a kind of superposition | 3 | | | | | | | |
| **Longitudinal waves:** | | | | | | | | |
| on a spring; wavelength, frequency, amplitude, period, wave speed | | 3 | | | 3 | | | |
| particle position, displacement, velocity, acceleration | | 4 | | | | | | |
| **Sound:** | | | | | | | | |
| pitch, loudness, quality (tone); | | 2 | | | 2 | | | |
| physics of the ear and hearing | | 2 | | | | | | |
| ultrasound and applications | | 2 | | | 2 | | | |
| Physics of music - standing waves in different kinds of instruments | | 4 | | | | | | |
| **Geometrical optics:** | | | | | | | | |
| Light rays, Reflection, Refraction, Mirrors, Total internal reflection, in various media | 3 | | | | | 3 | | |
| Snell's law | | | | | | 3 | | |
| Concave and convex mirrors | 4 | | | | | | | |
| Lenses, image formation, spectacles, microscopes, the eye, telescopes | | 4 | | | | | | |
| SALT, gravitational lenses | | 4 | | | | | | |
| **Doppler effect:** | | | | | | | | |
| With sound and ultrasound | | | 2 | 2 | | | 2 | 2 |
| With light – red shifts in the universe (evidence for expanding universe) | | | 4 | 4 | | | 4 | 4 |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| **Colour:** | | | | | | | | |
| Relationship to wavelength and frequency | | | 2 | 2 | | | | |
| Pigments, paints, Addition and subtraction of light | | | 2 | 2 | | | | |
| **2D and 3D wavefronts:** | | | | | | | | |
| single slit diffraction, constructive and destructive interference | | | 3 | 3 | | 3 | | |
| shock waves, sonic boom | | | 3 | | | | | |
| **Wave nature of matter:** | | | | | | | | |
| de Broglie wavelength, electron microscope | | | 4 | | | | | |
| Electricity and Magnetism | | | | | | | | |
| **Electrostatics:** | | | | | | | | |
| Two kinds of charge, Force between charges (qual), polarization, Conductors and insulators, discharge and lightning conductors | 2 | | | | 2 | | | |
| Charge quantization | | | | | 3 | | | |
| Force between charges (Coulomb's law) | | 3 | | 3 | | 3 | | 3 |
| electric field around single charges and groups of charges, electric field between parallel plates | | 4 | | 4 | | 4 | | 4 |
| Electrical potential energy and potential | | 4 | | 4 | | | | |
| capacitance, physics of the parallel plate capacitor, relation between charge, potential difference and capacitance, capacitor as a circuit device | | 3 | | 3 | | | | |
| **Electric circuits:** | | | | | | | | |
| Closed circuit, Elec potential difference (voltage), Current, Resistance, Principles and instruments of measurement of voltage (pd), current and resistance. (introductory) | 3 | | | | 3 | | | |
| Emf vs tpd | | | 3 | 3 | | | | 2 |
| Closed circuit, Elec potential difference (voltage), Current, Resistance, Principles and instruments of measurement of voltage (pd), current and resistance (advanced), relation between current, voltage and resistance (Ohm's law) | | 3 | | 3 | | 3 | | 3 |
| resistance, equivalent resistance, series, parallel networks | | 3 | | 3 | 3 | | | 3 |
| Purpose of Wheatstone bridge | | 4 | | | | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| Calculations with Wheatstone bridge | | 4 | | | | | | |
| Emf + internal resistance (quant) | | 3 | | 3 | | | 3 | 3 |
| Energy transfer in electric circuits, electrical power (calculations) | | | 3 | 3 | | 3 | | 3 |
| **Magnetism:** | | | | | | | | |
| Magnetic fields of permanent magnets, Poles of permanent magnets, attraction and repulsion, Earth's magnetic field, the compass | 3 | | | | 3 | | | |
| **Electromagnetism:** | | | | | | | | |
| magnetic field associated with current, current induced by changing magnetic field | | 3 | | 3 | | 3 | | 3 |
| Faraday's law | | 4 | | 4 | | 4 | | |
| Transformers, motion of a charged particle in a magnetic field | | 3 | | | | | | |
| **Electrodynamics:** | | | | | | | | |
| electrical machines (generators, motors) | | | 3 | 3 | | | 3 | 3 |
| alternating current | | | 2 | 2 | | | 2 | 2 |
| Capacitance and inductance | | | 4 | | | | | |
| **Electronics:** | | | | | | | | |
| capacitative and inductive circuits, filters and signal tuning, active circuit elements, diode, LED and field effect transistor, operational amplifier | | | 4 | | | | | |
| principles of digital electronics – logical gates, counting circuits | | | 4 | | | | | |
| **Electromagnetic radiation:** | | | | | | | | |
| dual (particle / wave) nature of EM radiation, nature of an EM wave as mutual induction of oscillating magnetic / electric fields, | | | 3 | 3 | 4 | | | |
| EM spectrum, Nature of EM as particle – energy of a photon related to frequency and wavelength, Penetrating ability | | | 3 | 3 | 4 | | | |
| Waves, legends and folkslores | | | | | 2 | | | |
| **MATTER AND MATERIALS** | | | | | | | | |
| **Observing, describing, classifying and using materials:** | | | | | | | | |
| Phases of matter, intermolecular forces | 2 | | | | 3 | 3 | | |
| Kinetic molecular theory | 2 | | | | 2 | 2 | | |
| Macroscopic properties, classify materials (macroscopic properties) | 1 | | | | | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| Materials (intro), Mixtures, Pure substances: elements and compounds, Names and formulae of substances | 1 | | | | 1 | | | |
| Metals, semi-metals and non-metals, Electrical conductors, semiconductors and insulators, Thermal conductors and insulators, Magnetic and nonmagnetic materials | 1 | | | | 1 | 1 | | |
| **Chemical bonding:** | | | | | | | | |
| Intramolecular forces (chemical bonds - covalent, ionic and metallic) | 3 | | | | 3 | | | |
| Intermolecular forces vs intramolecular forces | 3 | | | | | 3 | | 3 |
| **The atom: basic building block of all matter** | | | | | | | | |
| Orbit structure of the atom: protons, neutrons, electrons; isotopes, atomic number and atomic mass, isotopes | 2 | | | | 2 | | | |
| Models of the atom, atomic mass and diameter | 2 | | | | 2 | | | |
| Energy quantization and electron configuration | 4 | | | | 3 | | | |
| Periodic table, groups, periods, core and valence electrons, electron configuration for first 20 elements, groups, trends, metals and non-metals | 3 | | | | 3 | | | |
| Periodicity of ionization energy, Successive ionization energies | 4 | | | | 3 | | | |
| **Electronic properties of matter:** | | | | | | | | |
| Conduction in semiconductors, metals, ionic liquids | | 4 | | | | | | |
| Intrinsic properties and doping – properties by design, principles of the p-n junction and the junction diode, insulators, breakdown | | 4 | | | | | | |
| **Atomic combinations: molecular structure** | | | | | | | | |
| Chemical bond (electrostatic force), Lewis theory and Lewis diagrams, lone pairs | | 3 | | | | 3 | | |
| Dative covalent bonds | | | | | | 2 | | |
| Electronegativity, polar and non-polar molecules | | 2 | | | | 2 | | |
| Multiple bonds | | 2 | | | | 2 | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | **Gr 10** | **Gr 11** | **Gr 12** | **Matric exam** | **Gr 10** | **Gr 11** | **Gr 12** | **Matric exam** |
| Bond energy and length, Molecular shape as predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory | | 4 | | | | 4 | | |
| **Atomic nuclei:** | | | | | | | | |
| Nuclear structure and stability, Radioactivity, Ionising radiation, Fission and fusion and their consequences | | 4 | | | | | | |
| Nucleosynthesis – the sun and stars | | 4 | | | | | | |
| Age determination in geology and archeology | | 4 | | | | | | |
| **Ideal gases and thermal properties:** | | | | | | | | |
| Motion of particles, Kinetic theory of gases, Temperature and heating, pressure, Ideal gas law | | 3 | | | | 3 | | |
| **Optical phenomena and properties of materials:** | | | | | | | | |
| Transmission and scattering of light | | | 1 | 1 | | | | |
| Emission and absorption spectra | | | 2 | 2 | | | 2 | 2 |
| Lasers | | | 3 | 3 | | | | |
| Photoelectric effect | | | 3 | 3 | | | 3 | 3 |
| **Organic molecules:** | | | | | | | | |
| Organic molecular structures – functional groups, saturated and unsaturated structures, isomers | | | 3 | 3 | | | 3 | 3 |
| Systematic naming and formulae (up to 8 carbons): alkanes, alkenes, alkynes, alcohols, aldehydes, carboxylic acids, ketones | | | 3 | 3 | | | 3 | 3 |
| Systematic naming and formulae (up to 8 carbons): including benzene ring structure, amines, amides | | | 3 | | | | | |
| Structure and function relationships of organic molecules | | | 2 | 2 | | | 2 | 2 |
| Addition reactions | | | 3 | 3 | | | 3 | 3 |
| Substitution and elimination reactions, with applications | | | 3 | 3 | | | 3 | 3 |
| **Mechanical properties:** | | | | | | | | |
| Elasticity, plasticity, fracture, creep (qual) | | | 4 | | | | | |
| Hooke's law, stress-strain, ductile and brittle materials | | | 4 | | | | | |
| Fracture, strength of materials | | | 4 | | | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| **Organic macromolecules:** | | | | | | | | |
| Plastics and polymers – basic polymerization | | | 4 | | | | 4 | 4 |
| Plastics and polymers – thermoplastic and thermoset | | | 3 | | | | | |
| Biological macromolecules – structure, properties, function | | | 4 | | | | | |
| **CHEMICAL CHANGE** | | | | | | | | |
| **Physical and chemical change:** | | | | | | | | |
| Identify and distinguish between physical and chemical changes and examples, separating mixtures (physical and chemical) | 2 | | | | 2 | | | |
| Microscopic interpretation of macroscopic changes, Conservation of atoms and mass, Law of constant composition, Conservation of energy, Volume relationships in gaseous reactions | 2 | | | | 2 | | | |
| Decomposition and synthesis reactions, separation of particles | 3 | | | | | | | |
| **Representing chemical change:** | | | | | | | | |
| Balanced chemical equations | 3 | | | | 3 | | | 3 |
| **Quantitative aspects of chemical change:** | | | | | | | | |
| Atomic weights, Molecular and formula weights, Determining the composition of substances | | 3 | | | 3 | 4 | | |
| Amount of substance (mole), concentration | | 3 | | | 3 | 4 | | |
| Stoichiometric calculations, molar volume of gases | | 4 | | | 3 | 4 | | |
| Types of reactions: introductory reactions (acids & bases, redox reactions, gas forming) | | | | | 3 | | | |
| Types of reactions: substitution, addition and elimination (general) | | 3 | | | | | | |
| Types of reactions: redox reactions, oxidation numbers, oxidation and reduction | | 3 | | | | 3 | | |
| Acids and Bases, Arrhenius, Bronsted-Lowry, pH (concept) | | 3 | | | | 3 | | |
| Acids and Bases: Kw, Ka, Kb, pH calculations | | | | | | | 3 | 3 |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| Applications of acids and bases in hair | | | | | | | 2 | 2 |
| **Rate and extent of reaction:** | | | | | | | | |
| Endothermic and exothermic reactions | | 2 | | 2 | | 2 | | 2 |
| Energy changes in reactions, activation energy | | 2 | | 2 | | 2 | | 2 |
| Rates of reaction and factors affecting rate, measuring rates of reactions | | | 2 | 2 | | | 2 | 2 |
| Mechanism of reaction and of catalysis | | | 2 | 2 | | | 2 | 2 |
| Chemical equilibrium and factors affecting equilibrium | | | 2 | 2 | | | 2 | 2 |
| Equilibrium constant, application of equilibrium principles | | | 3 | 3 | | | 3 | 3 |
| **Electrochemical reactions:** | | | | | | | | |
| Electrolytic cells | | | 3 | 3 | | | 3 | 3 |
| Galvanic cells | | | 3 | 3 | | | 3 | 3 |
| Understanding of the processes and redox reactions taking place in cells, Standard electrode potentials, Writing equations representing oxidation and reduction half reactions and redox reactions | | | 3 | 3 | | | 3 | 3 |
| Relation of current and potential to rate and equilibrium, electrolytic cells | | | 3 | 3 | | | 3 | 3 |
| **CHEMICAL SYSTEMS** | | | | | | | | |
| **Global cycles:** | | | | | | | | |
| The water cycle - Physical changes and energy transfers, | 2 | | | | | | | |
| Properties of the three phases of water, macro vs micro properties | 2 | | | | | 2 | | |
| The nitrogen cycle - Chemical changes and energy transfers, Industrial fixation of nitrogen | 3 | | | | | | | |
| **The hydrosphere:** | | | | | | | | |
| Composition and interaction with other global systems | 2 | | | | 2 | | | |
| Ions in aqueous solution: their interaction and effects | 3 | | | | 3 | | | |
| Electrolytes and extent of ionization as measured by conductivity | 3 | | | | 3 | | | |
| Precipitation reactions | 2 | | | | 4 | | | |
| **Exploiting the lithosphere / earth's crust:** | | | | | | | | |
| Mining and mineral processing – gold, iron, phosphate, environmental impact of these activities | | 3 | | | | 2 | | |
| Energy resources and their use | | 2 | | | | | | |

| Table 1: Physical Sciences topics and sub-topics covered in the NCS and the CAPS (continued) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NCS 2 | | | | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | Matric exam | Gr 10 | Gr 11 | Gr 12 | Matric exam |
| **The atmosphere:** | | | | | | | | |
| Atmospheric chemistry | | 3 | | | | | | |
| Global warming and the environmental impact of population growth | | 3 | | | | | | |
| **Chemical Industries:** | | | | | | | | |
| Fuels, monomers and polymers, polymerisation, fractional distillation of crude oils | | | 3 | | | | | 3 |
| The chloralkali industry | | | 3 | 3 | | | | 3 |
| The fertilizer industry (N, P, K) | | | 3 | 3 | | | 3 | 3 |
| Batteries, torch, car etc | | | 3 | 3 | | | | |
| **Total Level 1** | **3** | **0** | **1** | **1** | **2** | **1** | **0** | **0** |
| **Total Level 2** | **16** | **11** | **9** | **13** | **17** | **11** | **8** | **14** |
| **Total Level 3** | **19** | **26** | **27** | **35** | **23** | **18** | **20** | **32** |
| **Total Level 4** | **8** | **16** | **15** | **6** | **6** | **7** | **4** | **6** |

It should be noted that the Grade 12 topics in the NCS that are not reflected in the 'Matric Exam' column were never actually taught in class, since they were never examinable.

### Table 2: Detailed skills coverage

Table 2 below presents the number of specific scientific skills per grade and across the FET Phase, clustered under four broad skill types.

| Table 2: Physical Science skills covered in CAPS | | | | |
|---|---|---|---|---|
| Skills | CAPS | | | |
| | Gr 10 | Gr 11 | Gr 12 | FET Phase |
| **PROBLEM SOLVING SKILLS** | | | | |
| Identify | 8 | 3 | 1 | 12 |
| Solve problems using arguments/reasoning | 1 | 3 | 2 | 6 |
| Solve problems using Mathematical skills | 11 | 11 | 10 | 32 |
| Convert units | 1 | 1 | | 2 |
| **Total Problem Solving** | **21** | **18** | **13** | **52** |
| **EXPERIMENTAL SKILLS** | | | | |
| Conduct a practical investigation | 5 | 2 | 1 | 8 |
| Design a practical investigation/project | | 2 | 2 | 4 |
| Draw conclusions | 5 | 7 | 8 | 20 |
| Evaluate an experiment | 1 | | | 1 |
| Conduct/follow steps of an experiment | 9 | 8 | 9 | 26 |

| Table 2: Physical Science skills covered in CAPS (continued) | | | | |
|---|---|---|---|---|
| Formulate a hypothesis | 2 | 2 | 1 | 5 |
| Interpret results | 9 | 7 | 9 | 25 |
| Interpret given data | 4 | | | 4 |
| Make inferences | 2 | | | 2 |
| Manipulate and read equipment | 13 | 9 | 10 | 32 |
| Record measurements / collect data | 8 | 7 | 9 | 24 |
| Understand experimental variables | 4 | 5 | 6 | 15 |
| Demonstrate | 8 | | 1 | 9 |
| Analysis (qualitative) | 2 | | | 2 |
| Present information | | | 1 | 1 |
| Conduct a survey/searching for information) | | | 4 | 4 |
| **Total Experimental** | **72** | **49** | **61** | **182** |
| **DIAGRAMMATIC / GRAPHICAL / TABULAR SKILLS** | | | | |
| Analyse a graph | 1 | 1 | 3 | 5 |
| Represent (draw) as a graph | 1 | | 3 | 4 |
| Represent (draw) schematic diagram | 7 | 9 | 4 | 20 |
| Reading a table (e.g. periodic table etc.) | 1 | | 1 | 2 |
| Represent using notation/ equations | 3 | | 5 | 8 |
| Interpretation of notation/equation | 1 | 2 | 2 | 5 |
| **Total Diagrammatic / Graphical / Tabular** | **14** | **12** | **18** | **44** |
| **DESCRIPTIVE / WRITTEN SKILLS** | | | | |
| Discuss | 3 | 3 | 2 | 8 |
| Explain | 13 | 9 | 11 | 33 |
| Compare and contrast | 4 | 3 | 3 | 10 |
| Construct scientific knowledge | 1 | | | 1 |
| Apply scientific knowledge | 2 | 3 | 7 | 12 |
| Classify | 2 | 1 | | 3 |
| Draw comparisons | 1 | | | 1 |
| Define/state | 15 | 10 | 11 | 36 |
| Use models | 7 | 2 | 1 | 10 |
| Write a report | 3 | 3 | 4 | 10 |
| Make an observation | 12 | 6 | 8 | 26 |
| Reproduce learned information (recall) | 12 | 9 | 8 | 29 |
| Describe | 14 | 6 | 5 | 25 |
| Verify | 1 | 2 | | 3 |
| List | 3 | 4 | 4 | 11 |
| Estimate | 1 | | | 1 |
| Deduce (relate) | 4 | 3 | 3 | 10 |
| Comprehend (understand) | 5 | 2 | 3 | 10 |
| Predict | 2 | | 1 | 3 |
| **Total Descriptive/Written** | **105** | **66** | **71** | **242** |
| **Total stipulation of skills** | **212** | **145** | **163** | **520** |

| Table 3: Modified Physical Science taxonomy | |
|---|---|
| **Level of cognitive demand** | **Type of cognitive demand** |
| **Lower order processes** | 1. Recognise or Recall (relates with Recall category from CAPS taxonomy) |
| | 2. Apply routine procedures or Re-organise given information (relates with Analysis, Application category from CAPS taxonomy) |
| **Middle order processes** | 3. Apply complex procedures involving interpretation, application and analysis (relates with Analysis, Application category from CAPS taxonomy) |
| | 4. Show understanding of physical science concepts, involving inference, interpretation and analysis (relates with Comprehension category from CAPS taxonomy) |
| **Higher order processes** | 5. Evaluate, Synthesise or Solve novel/ complex problems (relates with Evaluation, Synthesis category from CAPS taxonomy) |

37 General Van Ryneveld Street, Persequor Technopark, Pretoria
Telephone: +27 12 349 1510 • Fax: +27 12 349 1511
E-mail: info@umalusi.org.za • Web: www.umalusi.org.za

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Council for Quality Assurance in
General and Further Education and Training