AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

Analysis of the Brazilian National Learning Standards for Science

Version 3

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Contents

High Level Feedback

The Science course presents a balanced progression of learning across the years of schooling. Some previous recommendations have been taken into account in this version of the Science course. However, further suggestions have been made that will provide greater internal coherence and alignment with trends in international Science curricula.

The structure of Science in the BNLS compared with international trends

Theme Units

The new version of the Brazilian National Learning Standards for Science consists of five theme units across nine years of Elementary and Middle Schools, as did the previous version. However, some substantial changes have been made to the titles as well as the content of some of those themes, which greatly improves the coherence of the curriculum and brings it closer in line with international practice.

Table 1: BNLS Science Theme Units

BNLS Science (version 3)	BNLS Science (version 2)
Materials and Transformations	Materials, Properties and Transformations
From Organisms to Ecosystems	Environment, Resources and Responsibilities
The Earth and the Universe	Earth: Composition and Movement
Interactions and Energy	Senses, Perception and Interactions
Human Beings, Health and Quality of Life	Life: Constitution and Evolution

As per our previous advice, the theme 'Senses, Perception and Interactions' has been changed to 'Interactions and Energy' and now focuses exclusively on Learning Objectives related to the physical sciences. Some of its biology-related content has been incorporated into the new 'Human Beings, Health and Quality of Life' theme unit and a significant number of the previous objectives are no longer included in the new curriculum, thus reducing the overall dominance of the biological sciences, and allowing for the inclusion of more content from the physical sciences.

Also, a substantial redistribution of Learning Objectives related to the biological sciences has taken place. Their organisation into the new themes 'From Organisms to Ecosystems' and 'Human Beings, Health and Quality of Life' has greatly improved the thematic integrity of the proposed theme units and has brought the BLNS Science into closer agreement with most international Science curricula.

Knowledge Objects

'Knowledge Objects' have been introduced as an additional organising principle in the current version BNLS for Science, presumably with the intention of further structuring the disciplinary content into 'topics' or 'sub-themes'. This has the potential of greatly enhancing the clarity of the information presented, as well as allowing for easier identification of learning progressions across year levels.

If the afore-mentioned was indeed the intention of the 'Knowledge Objects', their effectiveness would be greatly enhanced by a more consistent choice of topics for each Knowledge Object, more consistent naming across year levels, and a closer alignment of the Learning Objectives with the corresponding Knowledge Objects.

For example, the theme unit *'Materials and Transformations'* contains the following Knowledge Objects and Learning Objectives in the first three years. (Text marked in green refers to material properties, orange to their uses, and blue to transformations.)

Year Level	Knowledge Objects	Learning Objectives
1	Materials: uses and transformations	(EF01CI01-04) Identify, based on investigation and observation, what materials (metals, wood, glass, etc.) everyday objects are made of, how those objects are used and what materials they were made of in the past. (EF01CI02) Identify and describe orally the transformations that everyday materials undergo (e.g. rusting and ice melting).
2	Properties of materials and their use	(New) Justify, based on investigation, the use of different materials in everyday utensils, considering some properties of those materials (resistance to heat and cold, flexibility, hardness, transparency, porosity, etc.). (EF02CI02) Test and describe, verbally or through drawings, changes in materials when they are exposed to different conditions (e.g. heating, cooling, light and humidity).
3	Materials, characteristics and uses Reversible and irreversible transformations	(EF03CI01) Compare characteristics of different materials and their suitability for different uses (e.g. buildings, manufacturing utensils and clothing). (New) Infer, based on investigation, that some changes caused by heating or cooling are reversible and others are not (e.g. changes of the state of water, boiling an egg, burning paper, etc.).

The year 2 Knowledge Object *'Properties of materials and their use'* has an equivalent in year 3, but with a slightly different name, i.e. *'Materials, characteristics and uses'*. Year 1 Knowledge Object *'Materials: uses and transformations'* combines uses and transformations rather than properties and uses. The year 2 Learning Objective EF02CI02 relates to transformations, while lacking a corresponding Knowledge Object in the same year level. In year 3 a separate Knowledge Object relating to transformations is present and aligns well with a corresponding Learning Objective, however, it is very specific with respect to the type of transformation.

In this particular example, clarity could be improved by choosing only two Knowledge Objects, e.g. *"Properties and uses of materials"* and *"Transformations"*. In the interest of creating a clear progression of learning, the sequence and content of Learning Objectives could be altered in such a way that the Knowledge Object *"Transformations"* is only introduced in the second year, e.g. by combining EF01CI02 and EF02CI02. This Knowledge Object may then progress through to later years, eventually containing Learning Objectives relating to chemical reactions. A possible altered version of the above example is given below.

Year Level	Knowledge Objects	Learning Objectives
1	Properties and uses of materials	(EF01CI01-04) Identify, based on investigation and observation, what materials (metals, wood, glass, etc.) everyday objects are made of, how those objects are used and what materials they were made of in the past.
2	Properties and uses of materials	(New) Justify, based on investigation, the use of different materials in everyday utensils, considering some properties of those materials (resistance to heat and cold, flexibility, hardness, transparency, porosity, etc.).
	Transformations	(EF01CI02 + EF02CI02) Test and describe, verbally or through drawings, changes in materials when they are exposed to different conditions (e.g. heating, cooling, light and humidity).
3	Properties and uses of materials	(EF03CI01) Compare characteristics of different materials and their suitability for different uses (e.g. buildings, manufacturing utensils and clothing).
	Transformations	(New) Infer, based on investigation, that some changes caused by heating or cooling are reversible and others are not (e.g. changes of the state of water, boiling an egg, burning paper, etc.).

While this approach may require some alterations to the content and/or sequence of Learning Objectives, it may be beneficial for a more progressive development of conceptual knowledge in the learning area.

Further, conceptually more demanding Knowledge Objects, such as, for example, *"Classification of Matter"*, *"Atomic Theory and Molecular Structure"* and/or objects relating to historical and cultural context, such as for example, *"Industrial processes and its impacts"*, could then be introduced at later year levels, while previous Knowledge Objects, like the proposed *"Properties and uses of materials"*, may be discontinued or suspended at some stage. The table depicted below is given purely as a means to exemplify this approach.

Knowledge Object	1	2	3	4	5	6	7	8	9
Properties and uses of materials									
Transformations									
Classification of Matter									
Atomic Theory and Molecular Structure									
Industrial processes and its impacts									

1. Recommendation:

- Create Knowledge Objects that can serve as organising principle across year levels, so that a progression of learning can be easily identified.
- Clearly align Learning Objectives to Knowledge Objects, so that each one belongs to a corresponding knowledge in the same year level.
- Use consistent naming of Knowledge Objects across year levels.
- Reduce the overall number of different Knowledge Objects within a theme unit to a maximum of 5 or 6.

Strands

The previous version of the BLNS Science had proposed the following strands:

1. Natural Science conceptual knowledge
2. Social, cultural and historical context in Natural Science
3. Processes and investigation practices in Natural Science
4. Natural Science languages

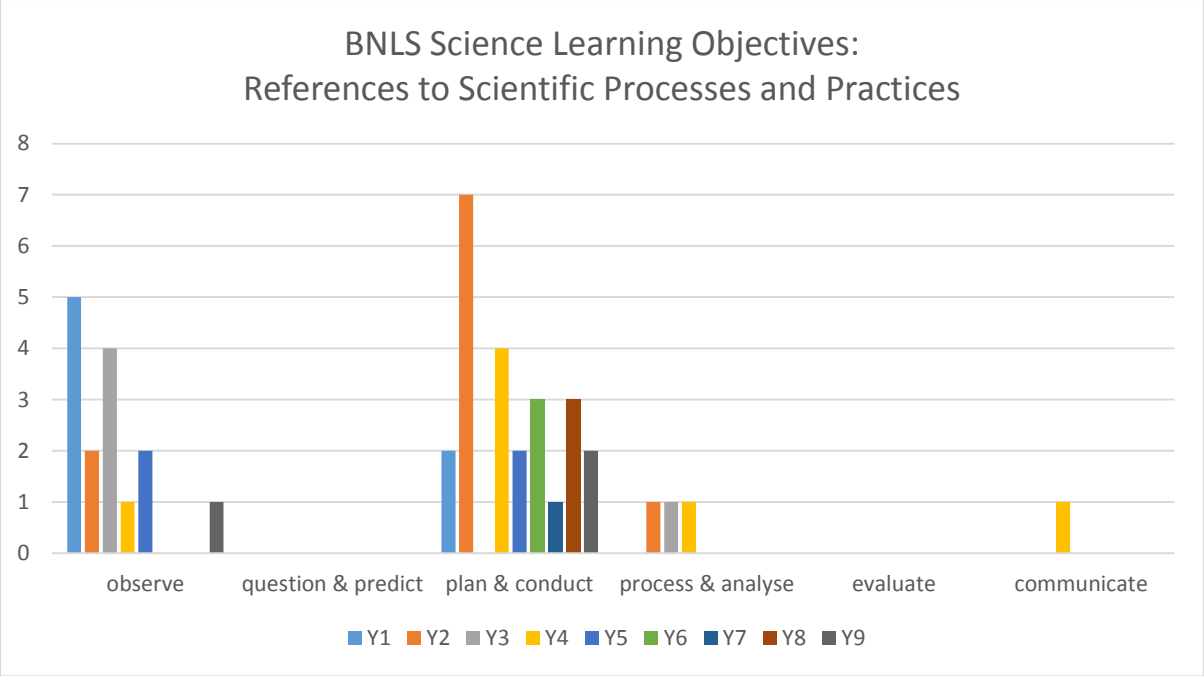
This organising principle, however, had not been applied to the organisation of the Learning Objectives. In the current version the separation of Learning Objectives into strands has not been continued or expanded. Instead, the Learning Objectives are written in an integrated way containing knowledge and/or context and/or processes. While such an integrated approach has its merits, in that it makes it very clear that teachers need to integrate the learning across all strands, it may make it difficult to clearly identify learning progressions within a strand. Recent national Science curricula tend to write separate Learning Objectives for

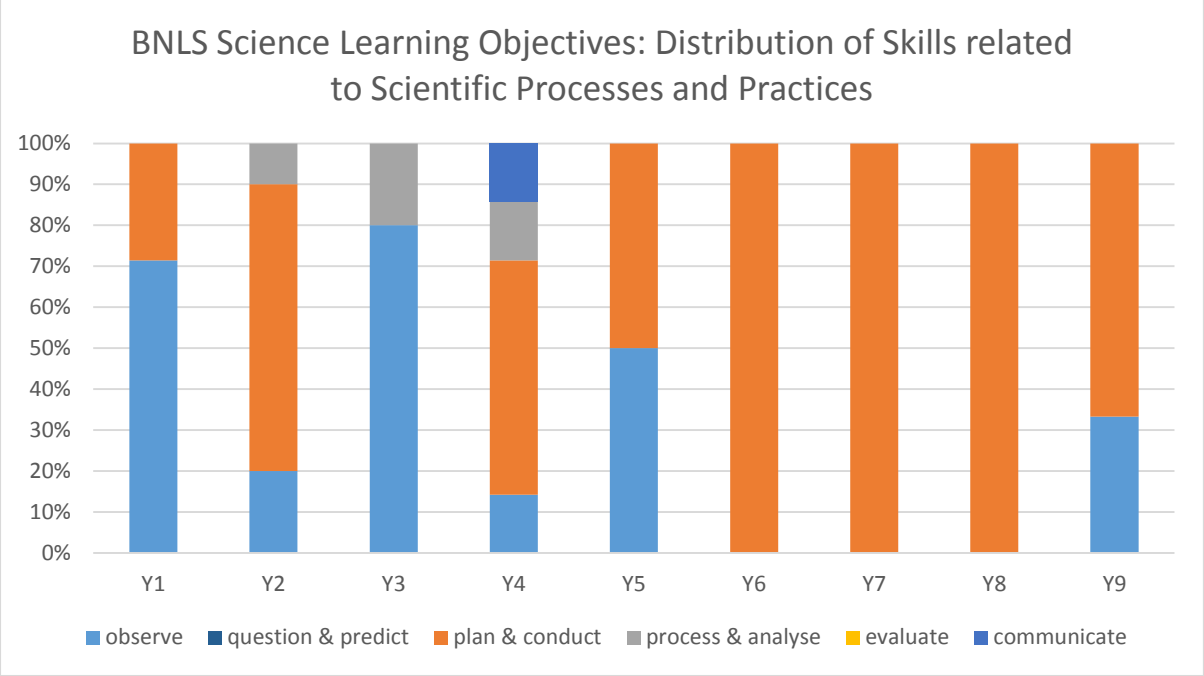
- disciplinary core knowledge and concepts,
- historic and cultural context, including contemporary socio-scientific issues, and
- skills related to scientific processes and practises.

Examples of such an approach can be found in the US Next Generation Science Standards, Singaporean Science Syllabus, British Columbia's New Curriculum, and the Australian Curriculum.

As demonstrated in the following graphs, the current version of the BNLS for Science lacks evidence of a progressive development of skills related to scientific processes and practises, such as

- questioning, predicting, and establishing hypotheses,
- planning and conducting experiments and investigations,
- processing and analysing data,
- evaluating methods and results, and
- communicating findings.





While many BLNS Learning Objectives do contain references to scientific processes and practises, they tend to be very brief statements in the form of supporting clauses such as *"…, based on investigation,…*" or *"…, through experimentation,…*", which do not contain the necessary detail required for defining a purposeful development of scientific inquiry skills and competencies.

Although 'observing' is not commonly stated explicitly as a separate skill related to scientific processes and practises, it can be regarded as an integral part of scientific investigation and has been included in this analysis due to its frequent mention.

‘Recording’ is the only skill addressed in the BLNS Learning Objectives that belongs in the group ‘processing and analysing data’, yet no mention of higher-order skills in this group is made, such as identifying trends and outliers in data, assuring precision or identifying bias.

2. Recommendation:

- Include specific Learning Objectives that address the individual skills required to gain new scientific knowledge through experiment and investigation.

It has been noted that the recommendation previously suggested to include a strand relating to scientific processes and practices has not been enacted. However, the inclusion of a such strand is still recommended so as to ensure the parity of the BNLS with international curricula. This process strand could underpin the five BNLS themes, as suggested in the table below.

Materials and Transformations	From Organisms to Ecosystems	The Earth and the Universe	Interactions and Energy	Human Beings, Health and Quality of Life
Scientific Processes and Practices				

Volume

There has been more content added into the BLNS by increasing the number of Learning Objectives in both the Elementary and Middle schools. It is assumed that not all Learning Objectives require an equal amount of time, but it is noteworthy that there has been approximately 50% more content added.

Strand	**BNLS v2**	**BNLS v3**	**AC**	**BCC**
conceptual knowledge and cultural and historical context	99	141	70	90
processes and practises	NA	NA	64	223

Consideration needs to be given to the value that these new Learning Objectives add to the quality of the learning that students will undertake when the BNLS is introduced.

Some of the new Learning Objectives are very specific in content and written in great detail, while thematically closely related to others within the same year level. An example from year 6, theme unit ‘The Earth and the Universe’ is given below:

> (New) Evaluate the possibilities and human limitations regarding space travels, based on a single-scale comparison of the diameter of the planets and their distance from the Sun.
>
> (New) Select arguments about the feasibility of human survival out of the Earth, based on the necessary conditions to live and the characteristics of planets, in order to debate the possibility of space colonisation.

A broader definition of those Learning Objectives would allow to combine them, reducing the overall number of objectives, while at the same time allowing for more teacher autonomy.

3. Recommendation:

- Evaluate the amount of content that has been included in the BNLS with regard to the time allocated to teaching Science within a whole learning programme.
- Broaden definitions of Learning Objectives that are closely related in content and combine them.

Measurability

The majority of Learning Objectives of the Science curriculum in Elementary and Middle schools are measurable. Most objectives begin with an observable and measurable verb. However, there are still a number of Learning Objectives that re now measurable. For example:

- Recognise
- Relate
- Associate

4. Recommendation:

The recommendation in previous advice was to replace verbs that are difficult to measure with verbs that result in an action or a performance that can be observed or measured. There are still a number of verbs included in the current document that would be difficult to measure.

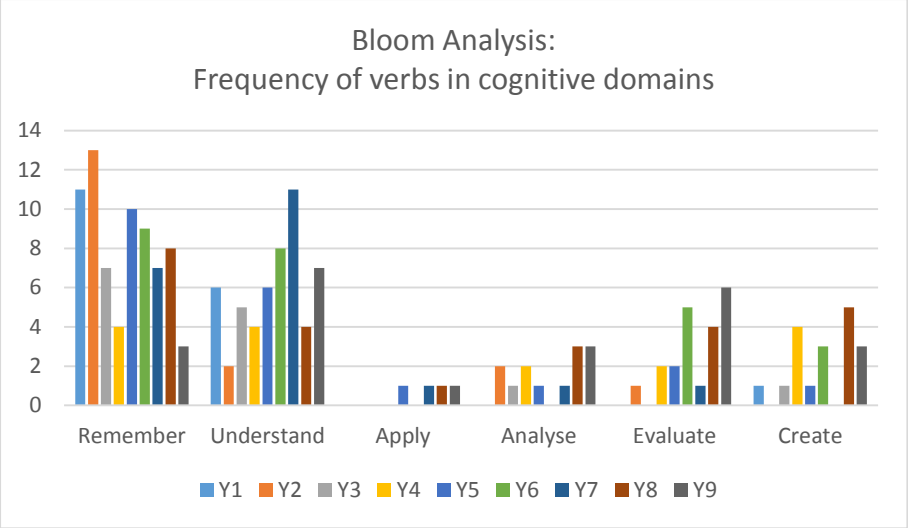
Academic rigour

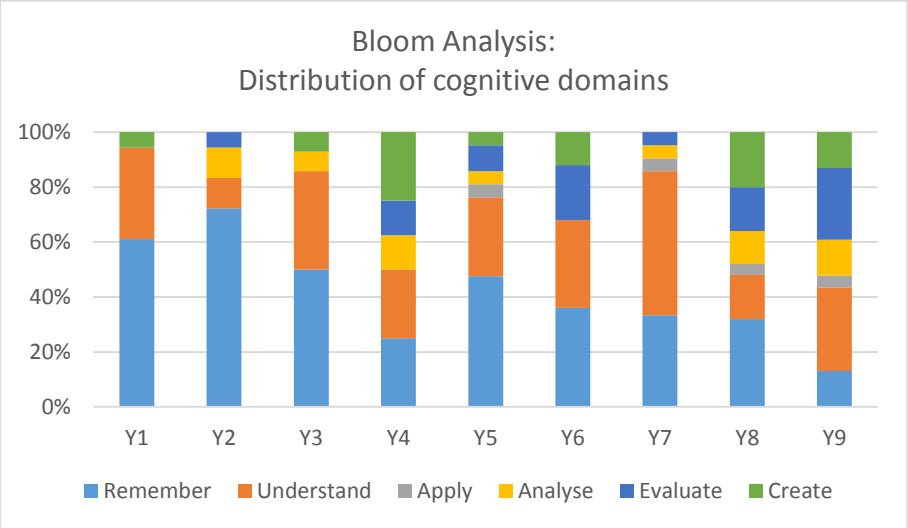
It is difficult to make judgement about the level of academic rigour of the Learning Objectives other than an analysis of the verbs used to describe the learning that takes place. Some of the following statements and comments may be influenced by the nature of the translation of the original wording.

There has been significant effort to incorporate the suggestion from previous advice to demonstrate the cognitive development of the conceptual demand of the Learning Objectives across the year levels by using a progression of verbs from lower to higher-ranking domains based on Bloom's taxonomy. While the most common verbs used to describe the Learning Objectives ('identify' and 'describe') still reflect the lowest level of cognitive demand according to Bloom, a clear progression towards more frequent use of verbs reflecting higher-order thinking, such as 'analyse', 'evaluate' and 'create' is clearly evident, as demonstrated in the following table and graphs.

Table: Categorisation of verbs used in BNLS Science Learning Objectives according to Bloom's taxonomy

Remember	Understand	Apply	Analyse	Evaluate	Create
Identify	Infer	Build	Characterise	Justify	Build
Describe	Compare	Apply	Deduct	Discuss	Design
Locate	Relate	Select methods	Discuss	Evaluate	Create
Name	Explain		Conclude	Debate	Propose
Recognise	Classify		Conduct	Interpret	Solve problem
Associate	Select examples		Analyse	Select/present arguments	Represent
Relate	Select reasons				Develop





A notable exception to the overall trend is year 7, where only 17% of the verbs used indicate higher cognitive demand – a proportion that appears to be too low for the year level.

5. Recommendation

- Revise the Learning Objectives to achieve a developmental sequence of verbs to demonstrate the progression of cognitive development across the years of schooling.

Clarity

The introductory sections of the document have been significantly reduced in volume and are more clearly structured than the previous version. They provide a clear rationale for the teaching of Science as a whole, as well as for the organisation of the learning area into the proposed theme units. They also provide guidance for teachers regarding the intention of the theme units with respect to the nature of the learner in Elementary and Middle school levels.

As was noted in the previous advice, the intention of the curriculum could be clearer with subheadings, bullet points, tables and diagrams to emphasise the key points of the purpose of the Science curriculum.

Knowledge Objects are consistently written in the form of topic headings. However, the wording of the Knowledge Objects referring to identical content often changes with year level and the way different topics are combined into a single Knowledge Object is inconsistent

across year levels. As noted previously, the clarity regarding the intent of the Knowledge Objects could be greatly improved by a more consistent approach.

The Learning Objectives are not written consistently in style throughout the BNLS for Science. Learning Objectives containing two or more sub-objectives sometimes are sometimes clearly separated by conjunctions (as in EF07CI07 below), whereas in other cases they are connected via qualifying clauses (EF07CI04).

> (EF07CI07) Compare different reproductive processes and identify advantages and disadvantages of each one of them.
>
> (EF07CI04) Identify and characterise the processes involved in photosynthesis, relating photosynthesis to the primary production of food.

The latter gives rise ambiguity, which may, of course, be an issue related to the translation of the original wording. To improve the clarity of the Learning Objectives, individual sub-objectives should be clearly separated, if required in a separate sentence. E.g.

> (EF07CI04) Identify and characterise the processes involved in photosynthesis. Relate photosynthesis to the primary production of food.

6. Recommendation

- Introduce subheadings, bullet points, tables and/or diagrams to the introductory text in order to emphasise the key points of the purpose of the Science curriculum and its structural organisation.
- Separate individual sub-objectives within Learning Objectives clearly using 'and' conjunctions or, if necessary, use separate sentences.

Pitch, progression and sequence

The Learning Objectives of the BNLS for Science are mostly age appropriate and demonstrate a reasonable progression of learning within each theme unit. In some instances, however, issues with pitch as well as sequence of Learning Objectives have been identified.

For example, the year 8 content of the theme unit *'Materials and Transformations'* specifies the Learning Objective

> (New) Infer, based on the analysis of graphs and/or tables, that matter is conserved in chemical transformations.

While, strictly speaking, this objective does not rely on the knowledge of the particle nature of matter, it is unusual and contrary to international practice to teach the principle of conservation of matter in chemical reactions prior to the introduction of the atomic theory of matter, which in the BLNS Science is only introduced in year 9:

> (New) Develop models to describe the structure of matter (atomic constitution and composition of simple molecules).

A similar issue has been identified in the theme unit *'Interactions and Energy'*, where two Learning Objectives specified for year 8 relate to the socio-environmental aspects of energy generation and use:

> (EF05CI04) Propose collective actions to optimise the use of electrical energy at school and/or in the community, based on the selection of equipment according to sustainability criteria (energy consumption and efficiency) and habits of use.
>
> (EF05CI05) Discuss and evaluate electrical energy generation systems, their socio-environmental impacts and how electricity reaches and is used at students' cities, communities, homes and schools.

However, the concept of transformation of energy between different forms (kinetic, heat, electrical, …) is not addressed in any of the Learning Objectives. Students would probably find it difficult to be able to discuss and evaluate different forms of energy generations and their efficiencies without a sound understanding of the underlying physical principles.

The theme unit *'The Earth and the Universe'* specifies the year 5 Learning Objective

> (New) Relate regional climate characteristics to the local latitude and the corresponding season of the year.

However, the underlying principles responsible for the latitudinal variation of climate and seasonal changes is not covered until year 8:

> (New) Represent, in a three-dimensional model, the Earth's rotation and revolution and analyse the role of the Earth's axial tilt in the seasons of the year.
>
> (EF08CI07) Relate regional climate to the unequal heating of the Earth, the atmospheric and ocean circulation patterns and the movements of the Earth.

This prompts the question of how students are to understand the content of the year 5 Learning Objective.

The Learning Objectives relating to infectious diseases and vaccination in year 6 of the theme unit *'Human Beings, Health and Quality of Life'* appear to be pitched too high.

> (EF05CI09) Infer, from the knowledge of the mode of transmission of protozoa, viruses and bacteria, the main prevention and treatment actions and measures, and propose concrete actions to promote individual and public health.
>
> (New) Present arguments about the importance of vaccination to public healthcare, based on information about the mechanism of action of vaccines in the body and the historical role of vaccination to maintain individual and public health and to eradicate diseases.

Since students at this year level have not yet been introduced to the fundamental concepts of cell biology, which are covered in year 7 of the theme unit *'From Organisms to Ecosystems'*, they would find it difficult to understand "the mode of transmission of protozoa, viruses and bacteria" or "the mechanism of action of vaccines" to the level of detail and academic rigour that was (presumably) intended here.

7. Recommendation:

- Consider introducing the atomic theory of matter in year 8, which is closer in alignment with international Science curricula.
- Introduce Learning Objectives that focus more on the physical principles of energy and its transformations.
- Revise the pitch of some Learning Objectives in the theme unit *'The Earth and the Universe'.*
- Consider aligning the content of unit themes *'Human Beings, Health and Quality of Life'* and *'From Organisms to Ecosystems'*, so that students are already familiar with the fundamental principles of cell biology before introducing the Learning Objectives relating to infectious diseases and vaccination.

Summary of Recommendations:

1.

- Create Knowledge Objects that can serve as organising principle across year levels, so that a progression of learning can be easily identified.
- Clearly align Learning Objectives to Knowledge Objects, so that each one belongs to a corresponding knowledge in the same year level.
- Use consistent naming of Knowledge Objects across year levels.
- Reduce the overall number of different Knowledge Objects within a theme unit to a maximum of 5 or 6.

2.

- Include specific Learning Objectives that address the individual skills required to gain new scientific knowledge through experiment and investigation.

3.

- Evaluate the amount of content that has been included in the BNLS with regard to the time allocated to teaching Science within a whole learning programme.
- Broaden definitions of Learning Objectives that are closely related in content and combine them.

4.

- The recommendation in previous advice was to replace verbs that are difficult to measure with verbs that result in an action or a performance that can be observed or measured. There are still a number of verbs included in the current document that would be difficult to measure.

5.

- Revise the Learning Objectives to achieve a developmental sequence of verbs to demonstrate the progression of cognitive development across the years of schooling.

6.

- Introduce subheadings, bullet points, tables and/or diagrams to the introductory text in order to emphasise the key points of the purpose of the Science curriculum and its structural organisation.
- Separate individual sub-objectives within Learning Objectives clearly using 'and' conjunctions or, if necessary, use separate sentences.

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