# DP Country Alignment Studies: Alignment of the Diploma Programme with the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS)

**Submitted by Ecctis to the IB**

**Commercial in confidence**

**October 2022**

## Acronyms

| | |
|---|---|
| **AA** | mathematics: analysis and approaches |
| **AHL** | additional higher level |
| **AI** | mathematics: applications and interpretation |
| **ATL** | approaches to teaching and learning |
| **CAS** | creativity, activity, service |
| **CCSS** | Common Core State Standards |
| **CCSSM** | Common Core State Standards for Mathematics |
| **CP** | Career-related Programme |
| **DP** | Diploma Programme |
| **English LL** | English A: language and literature |
| **HL** | higher level |
| **HS** | High School |
| **IB** | International Baccalaureate |
| **IBO** | International Baccalaureate Organisation |
| **LO** | Learning Outcome |
| **LS** | Life Sciences |
| **MCQ** | Multiple Choice Question |
| **MYP** | Middle Years Programme |
| **NGSS** | Next Generation Science Standards |
| **PS** | Physical Sciences |
| **PYP** | Primary Years Programme |
| **RQ** | Research Question |
| **SL** | standard level |
| **TOK** | theory of knowledge |
| **USA** | United States of America |

# Contents

# 1. Executive Summary

## Project Aims and Context

The International Baccalaureate (IB) Organization is a not-for-profit educational foundation offering four programmes across the world. One of them – the Diploma Programme (DP) – is a two-year upper secondary programme, primarily intended to prepare students for university matriculation and higher education.

Ecctis was commissioned by the IB to deliver a series of in-depth studies to assess the level of alignment between the DP and comparison points within the upper secondary education systems of Australia, Canada, the United States of America (USA), Singapore, South Korea, and Finland. More specifically, the studies aim to identify areas of similarities and differences between the DP and these educational systems to inform the IB's development of tools and resources for IB teachers, ultimately helping them navigate between the DP and the local curriculum in the target countries. In doing so, the studies also contribute to further supporting fair recognition of the DP by institutions, employers, and other key stakeholders, supporting progression and mobility for DP holders. The studies include, for all countries, a focus on mathematics and the sciences, with an additional focus on history for Australia, and English for the USA.

This report aims to specifically evaluate alignment between the DP and the upper-secondary Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS).

## Research Questions and Methods

All comparative studies in this series have been framed by responses to Research Questions (RQs), both at programme and subject levels. For this study, these RQs were the following:

**RQ1:** To what degree do DP English and mathematics curricula align with the CCSS for grades 11 and 12?
1.1: In what way are DP curricula and the CCSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and in which areas do they not meet the expectations of the CCSS?
1.2: How do DP expected learning outcomes compare with the CCSS in terms of demand and difficulty?

**RQ2**: To what degree do the DP science curricula align with the NGSS for grades 11 and 12?
2.1: In what way are DP curricula and the NGSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and which areas do they not meet the expectations of the NGSS?
2.2: How do DP expected learning outcomes compare with the NGSS in terms of demand and difficulty?

**RQ3**: How do DP curricula compare with the CCSS/NGSS in regard to:
3.1: Content
- Structure
- Topics (including relationship among topics and progression of content).

3.2: Expected learning outcomes
- Knowledge

- Competencies (subject-specific skills, college and career readiness competencies, including learning progressions)

To answer the above RQs, Ecctis developed and applied a bespoke methodology.

At programme-level, this involved the comparative analysis of key components of the DP and the CCSS and NGSS, including: philosophical underpinnings, structure, requirements and associated outcomes, student learning pathways, and assessment methods (where possible). At subject-level, it involved the comparative analysis of key components of specific subjects in the DP and the standards, including: learning outcomes, content, and demand.

Where appropriate, Ecctis complemented its standard comparative methodology with a comprehensive mapping method, extracting themes from the DP to evaluate their presence in the comparison point(s). Additionally, to assess demand at subject level, Ecctis designed and deployed an expert panel approach, scoring each individual subject against a common set of demand criteria.[1]

## Key Findings

### Programme-level

Given that the CCSS and NGSS are standards and not full programmes of study, they are implemented differently by each signatory state. Thus, it is not possible to comment on programme-level alignment without commenting on how each CCSS and NGSS signatory state implements the standards in their own jurisdictions, a process which is beyond the scope of this project.

This being said, Ecctis did identify some potential similarities between the philosophical underpinnings of the DP and the standards, with overlap particularly around the emphasis on developing students' higher-order thinking skills.

### Subject-level

In this study, Ecctis carried out comparative analysis between the DP and the CCSS and NGSS on the subjects of English, mathematics, physics, chemistry and biology, focusing on the following DP and comparison subjects:

*Table: Subject areas for comparison of the DP and the CCSS and NGSS curricula*

| DP subject (group) | CCSS and NGSS |
|---|---|
| *SCIENCES* | |
| biology SL & HL | Life Sciences standards (high school) (NGSS life sciences) |
| chemistry SL & HL | Physical Sciences standards (high school) (NGSS physical sciences) |
| physics SL & HL | Physical Sciences standards (high school) (NGSS physical sciences) |
| *MATHEMATICS* | |

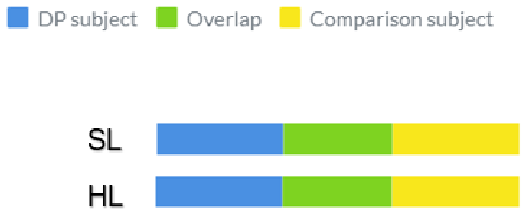
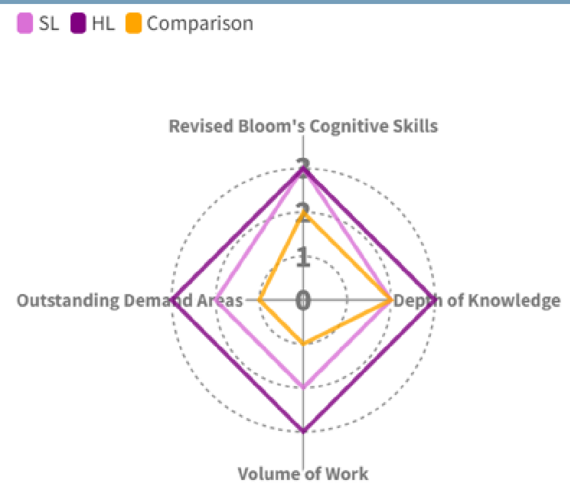
[1] Each individual subject was scored for: cognitive skills evidenced in the learning outcomes (based on the Revised Bloom's Taxonomy), depth of knowledge (adapted from Webb's Depth of Knowledge levels), volume of work (a tri-factor score considering breadth, depth and allocated timeframe), and outstanding areas of subject demand (stretch areas).

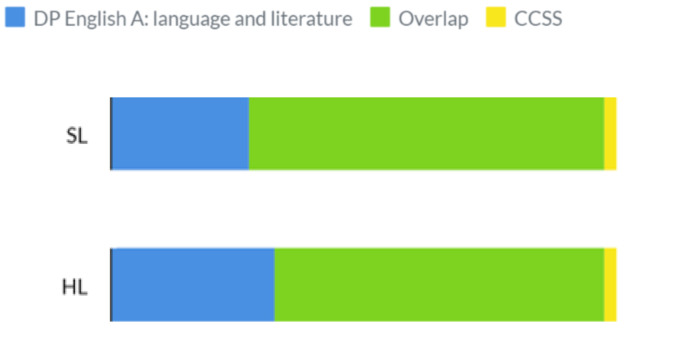
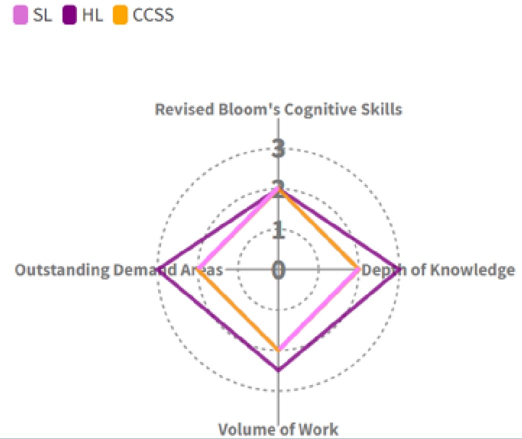
| | |
|---|---|
| mathematics: analysis and approaches (AA) SL & HL | Common Core State Standards for Mathematics (high school) (CCSSM) |
| mathematics: applications and interpretation (AI) SL & HL | |
| *ENGLISH* | |
| English A: language and literature (English LL) SL & HL | Common Core State Standards for English Language Arts (CCSS English) |

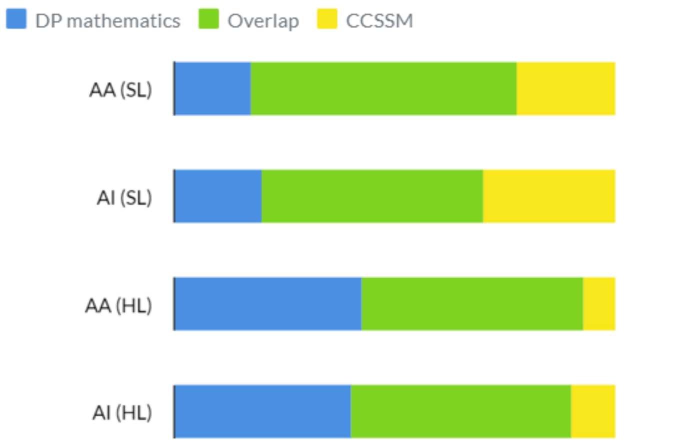
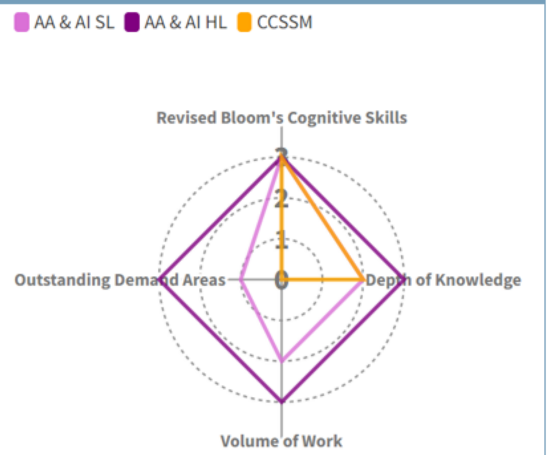
The findings from the subject-level analysis are summarised in the tables below:

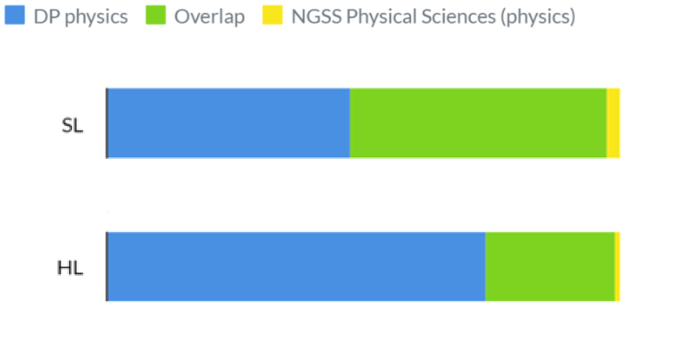
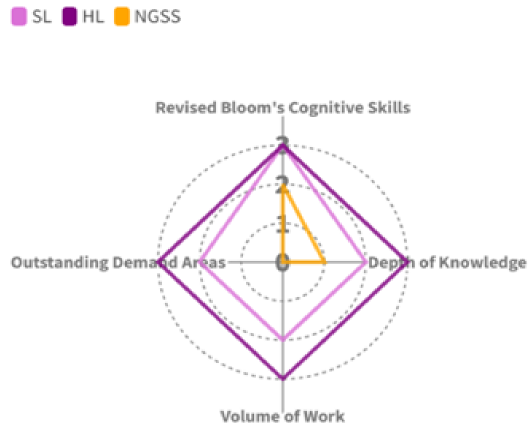
*Figures: Visual representations of alignment between DP subjects and comparison subjects*

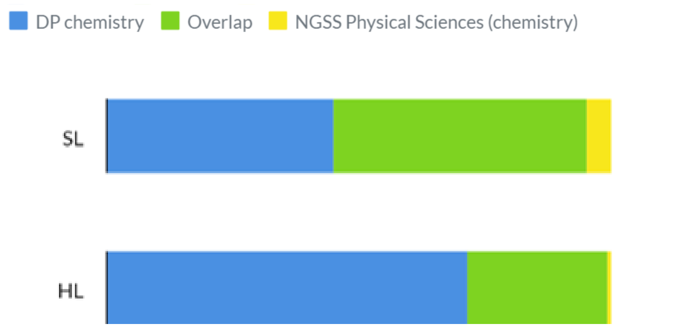
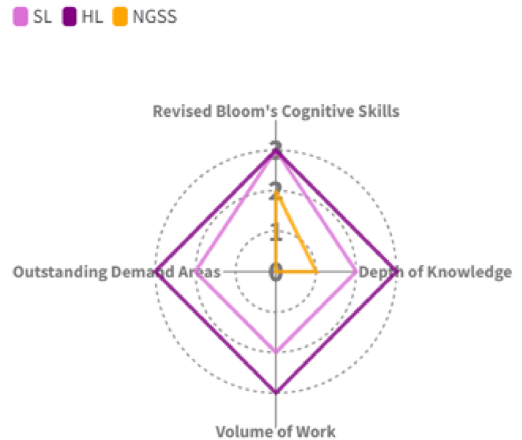
*Key:*

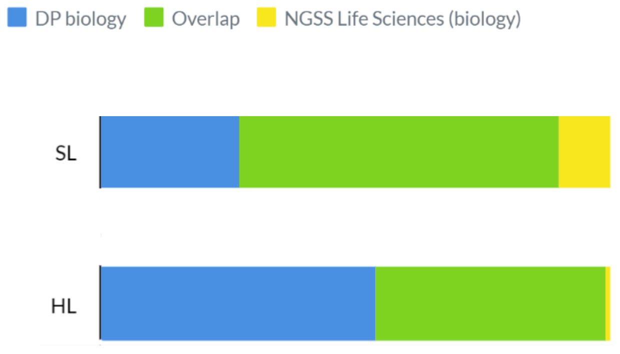
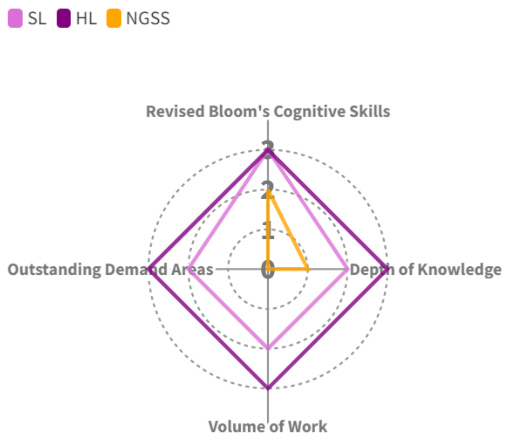
| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Displays the name of the comparison subject | Low<br>**Moderate**<br>High<br><br>This represents the learning outcome alignment between the DP subject and the comparison subject. A black border is placed around the selected judgement – 'Moderate' in this example. | <br>These bars represent the content alignment between the DP subject and the comparison. There is one bar showing alignment with SL content and another for HL content (inclusive of SL content). The **green** section of the bar represents the overlap of content between the subjects. The **blue** section represents content which was in the DP subject only. The **yellow** section represents content which was in the comparison subject only. Therefore, if, say, the blue section was longer than the yellow, this can be interpreted as the DP subject having more content unique to itself than the comparison did. A large green bar would indicate that a substantial proportion of content is common to both the DP and comparison subject. | <br>This radar diagram displays the demand judgement scores for the comparison subject(s) and the DP subject – both SL and HL. |

<table>
<tr><th>Subject name</th><th>Learning outcomes alignment</th><th>Content alignment</th><th>Demand alignment</th></tr>
<tr><td>CCSS English</td><td>Low<br>Moderate<br>High</td><td>
</td><td>
</td></tr>
</table>

<table>
<tr><th>Subject name</th><th>Learning outcomes alignment</th><th>Content alignment</th><th>Demand alignment</th></tr>
<tr><td>CCSSM</td><td>Low<br>Moderate<br>High</td><td>
</td><td>
</td></tr>
</table>

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Physical Sciences (physics) | Low<br>Moderate<br>**High** |   |   |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Physical Sciences (chemistry) | Low<br>Moderate<br>**High** |   |   |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Life Sciences (biology) | Low<br>Moderate<br>**High** |  |  |

As well as alignment judgements, the analysis also uncovered various similarities and differences between the DP and comparison subjects – the section below summarises the key ones for each subject.

*English*

- **Learning outcomes alignment**: the level of alignment between the learning outcomes in the DP English LL and the CCSS English is significant. Despite some differences in emphasis – for example, the CCSS require students to explicitly show technical competence and understanding of standard English in communication whereas the DP's requirements in this area are broader – all outcome themes extracted from the DP are present to at least some extent in the CCSS.

- **Content alignment**: the DP enables greater depth in content, particularly by encouraging metacognitive thinking. Regarding text choice, the DP is more prescriptive in what reading is allowed, whereas the CCSS have the potential to cover a larger range of texts. Generally, the DP includes most of the content described in the CCSS, as well as unique additional content.

- **Demand alignment**: the CCSS English are strongly aligned with the DP English LL SL course in demand, scoring the same for all categories. Meanwhile, the DP English LL HL scores higher for volume of work, depth of knowledge and number of stretch areas.

*Mathematics*

- **Learning outcomes alignment**: the level of alignment between both DP mathematics subjects, at both SL and HL, and the CCSSM learning outcomes is moderate. The DP and CCSSM share similar learning outcome themes involving critical thinking skills, use of technology, understanding and application, forming links and generalisations, communication skills, and learning skills. However, DP themes involving wider contexts and inquiry-based approaches are not evident in the CCSSM.

- **Content alignment**: the level of content alignment between DP mathematics subjects and the CCSSM varies. The AA SL and CCSSM have the most content overlap, though the CCSSM do not share any calculus content, contain different geometry material and feature only a few additional higher level (AHL) sub-topics. Moreover, the CCSSM do not contain enough AHL content to have significant overlap with HL overall. In summary, the CCSSM have slightly more depth in some topics than the DP SL subjects, but less breadth; and have both less breadth and depth than HL subjects.

- **Demand alignment**: all DP mathematics courses, both at SL and HL, considerably surpass the CCSSM in demand in terms of volume of work and stretch areas.

*Physics, chemistry, and biology*

All DP science subjects – physics, chemistry and biology – have been individually analysed and compared against the designated comparison subject. However, as they share a number of similarities – for instance, the same learning outcomes, assessment objectives and assessment requirements – the findings for all courses were similar and are, thus, collectively presented below.

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of the DP science courses and those of the NGSS is high, with most themes extracted from the DP learning outcomes being present in the NGSS's learning outcomes. Indeed, the NGSS also demonstrate a focus on scientific inquiry, critical thinking skills, and communication. However, there are slight differences with regards to the emphasis of certain themes, with the NGSS having a lesser focus on scientific implications and conceptual understanding and a greater focus on use of models and computational thinking.

- **Content alignment**: while there is some significant topic and sub-topic overlap between the NGSS and the DP science courses at SL, any alignment between the NGSS and DP AHL content is very limited. As to content depth and level of detail covered, these are considerably higher in the DP science courses, at both SL and HL, than in the NGSS. HL, in particular, includes a considerable amount of additional content not explicitly covered in the NGSS. From the three DP science subjects, chemistry observed the lowest level of content alignment with the DP overall, as the chemistry-specific content covered by the NGSS is limited.

- **Demand alignment**: the DP science courses, both at SL and HL, considerably surpass the NGSS in demand level. The NGSS score lower in all categories, with particularly strong differences noted in outstanding areas of demand and volume of work. The NGSS do, however, score more closely to the DP when it comes to cognitive skills, as there is evidence of some higher-order thinking skills, such as analysis.

### Summary

As standards, rather than full programmes of study, the CCSS and NGSS lack many of the components of a full programme, meaning that an alignment judgement at programme-level is not possible. At subject-level, the CCSS for English were found to be moderately to highly aligned with the DP's English LL subject and the CCSSM moderately aligned with both mathematics subjects, with higher alignment found at SL than at HL. As to the NGSS, these were found to be only weakly to moderately aligned with the DP science subjects – physics, chemistry and biology – as they cover less content and were judged to be less demanding than the latter.

# 2. Introduction

## 2.1 Context and Scope

The International Baccalaureate (IB) Organization is a not-for-profit educational foundation offering four programmes across the world, including the Primary Years Programme (PYP), Middle Years Programme (MYP), the Diploma Programme (DP), and the Career-related Programme (CP). The DP – the IB's two-year upper secondary Diploma Programme – is conceived as a preparatory programme for university matriculation and higher education, aimed at developing students with 'excellent breadth and depth of knowledge' who 'flourish physically, intellectually, emotionally and ethically'.[2]

Ecctis was commissioned by the IB to deliver a series of critical and in-depth alignment studies to assess the level of alignment between the DP and comparison points within the upper secondary education systems of Australia, Canada, the USA, Singapore, South Korea, and Finland.[3] More specifically, the studies aim to identify areas of similarities and differences between the DP and these educational systems by comparing philosophical underpinnings, curriculum structure, requirements, assessment methods, learning pathways, content, and specifically to determine how the DP compares to the selected benchmarks in terms of intended student learning outcomes at subject level. The studies include, for all countries, a focus on mathematics and the sciences, with an additional focus on history for Australia, and English for the USA.

Ultimately, this series of comparative studies aims to inform the IB's development of tools and resources for IB teachers, helping them navigate between the IB and the local curriculum in the target countries where needed. In doing so, it also contributes to further supporting fair recognition of the DP by institutions, employers, and other key stakeholders, supporting progression and mobility for DP holders.

This report constitutes one of the project's deliverables and aims to specifically answer the research questions pertaining to how the DP aligns with the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS).

## 2.2 Research Questions

All comparative studies in this series have been framed by responses to Research Questions (RQs), both at programme level and subject level. For this study specifically, the RQs are as follows:

[2] International Baccalaureate. (2022). *Diploma Programme*. https://www.ibo.org/programmes/diploma-programme/

[3] The series of studies responds to the following Request for Proposals (RFP), issued by the IB: *The International Baccalaureate Diploma Programme: Alignment with Australian and Canadian Upper Secondary Education; Request for Proposals (RFP): The International Baccalaureate Diploma Programme: Alignment with the Common Core State Standards (CCSS) and the New Generation Science Standards (NGSS); Request for Proposals (RFP): The International Baccalaureate Diploma Programme: Alignment with Singaporean, Korean and Finnish Upper Secondary Education.*

## Common Core State Standards and Next Generation Science Standards Research Questions

*Table 1: CCSS and NGSS research questions*

| |
|---|
| **RQ1:** To what degree do DP English and mathematics curricula align with the CCSS for grades 11 and 12?<br>1.1: In what way are DP curricula and the CCSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and in which areas do they not meet the expectations of the CCSS?<br>1.2: How do DP expected learning outcomes compare with the CCSS in terms of demand and difficulty?<br><br>**RQ2**: To what degree do the DP science curricula align with the NGSS for grades 11 and 12?<br>2.1: In what way are DP curricula and the NGSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and which areas do they not meet the expectations of the NGSS?<br>2.2: How do DP expected learning outcomes compare with the NGSS in terms of demand and difficulty?<br><br>**RQ3**: How do DP curricula compare with the CCSS/NGSS in regard to:<br>3.1: Content<br>• Structure<br>• Topics (including relationship among topics and progression of content).<br>3.2: Expected learning outcomes<br>• Knowledge<br>• Competencies (subject-specific skills, college and career readiness competencies, including learning progressions) |

With regards to subjects to be compared in the subject-level comparative analysis, the following table indicates the agreed scope:

*Table 2: Subject areas for comparison of the DP and the CCSS and NGSS curricula*

| **DP subject (group)** | **CCSS and NGSS** |
|---|---|
| *SCIENCES* | |
| biology SL and HL | Life Sciences standards (high school) |
| chemistry SL and HL | Physical Sciences standards (high school) |
| physics SL and HL | Physical Sciences standards (high school) |
| *MATHEMATICS* | |
| mathematics: analysis and approaches SL and HL | Common Core State Standards for Mathematics (high school) |
| mathematics: applications and interpretation SL and HL | |
| *ENGLISH* | |
| English A: language and literature SL and HL | Common Core State Standards for English Language Arts (high school) |

All DP curricula has been considered at both standard level (SL) and higher level (HL).

## 2.3 Report Structure

In responding to the above research questions, this report includes the following sections:

- 3. Methodology: this section provides a brief overview of the methodology applied in this study. This includes details of how the document selection and identification of comparison points for the study took place; a definition of ‘alignment’; an outline of the methodology used for comparisons at both programme and subject levels; and an outline of the methodology used to assess demand.

- 4. Programme-Level Alignment: this section presents the synthesised analysis from the programme-level comparisons between the DP and the CCSS and NGSS. In doing so, it includes brief overviews of each, followed by the comparative analysis on their philosophical underpinnings, structure, requirements and associated outcomes, student learning pathways and the general nature of assessment practices.

- 5. Subject-Level Alignment: this section presents the synthesised analysis from the subject-level comparisons between the DP and the CCSS and NGSS. For each comparison subject, this includes the comparative analysis on their learning outcomes, content, and demand.

- 6. Key Findings: this section outlines the key findings from both the programme- and subject-level comparisons undertaken in this study. In doing so, it provides a succinct summary of key similarities and key differences at both programme and subject levels.

- 7. Bibliography: this section references all sources cited in the study, including the documents used for both programme- and subject-level analyses.

# 3. Methodology

## 3.1 Document Selection and Identification of Comparison Points

To undertake these comparative analyses, the following core documentation was reviewed (supplemented by additional documentation – detailed in the Bibliography – where relevant and available):

### IB Documentation

- What is an IB education? (WIABE)
- WIAIBE Teacher Support Material
- DP: From principles into practice
- Programme Standards and Practices
- DP subject guides:
    - mathematics: analysis and approaches
    - mathematics: applications and interpretation
    - biology
    - chemistry
    - physics
    - Language A: language and literature.

### CCSS and NGSS Documentation

- The ‘About the Standards’ section in the CCSS website[4] and the ‘Principles of the Framework’ section in the NGSS website,[5] including information about underpinning philosophy and pedagogy
- The CCSS for:
    - Mathematics Standards (high school)
    - English Language Art Standards (grades 11 and 12)
- The NGSS for:
    - Life Sciences (high school)
    - Physical Sciences (high school)

### Philosophical Underpinnings Comparison

For the programme-level comparisons between the philosophical underpinnings of each programme, Ecctis used the following elements of the documentation:

*Table 3: Philosophical underpinnings for comparison of the DP and the CCSS and NGSS*

| Documentation containing philosophical underpinnings | |
|---|---|
| **DP** | **CCSS and NGSS** |
| ‘What is an IB Education’, particularly the following sections:<br>○ IB learner profile<br>○ International-mindedness | CCSS and NGSS websites and publications, particularly the following sections: |

[4]National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards.* http://www.corestandards.org/about-the-standards/
[5] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. https://doi.org/10.17226/13165

| | |
|---|---|
| ○ Approaches to teaching and approaches to learning (ATL).[6] | ○ CCSS website: 'About the Standards'[7]<br>○ NGSS: 'Principles of the Framework' from the 'A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas' document.[8] |

While the document 'What is an IB Education?' provides detailed information about the IB's educational philosophy, the philosophy and pedagogy of the CCSS and NGSS are articulated to a lesser extent in the available documentation on the frameworks. Nevertheless, the 'About the Standards' section from the CCSS website and 'Principles of the Framework' section of the 'A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas' document were deemed to provide sufficient detail for a meaningful comparison of the philosophical underpinnings of the DP and CCSS and NGSS.

For more information on the mapping process, see the Measuring Alignment section below.

## Learning Outcomes Comparison

For the Learning Outcomes (LOs) comparisons, as neither the DP nor the CCSS and NGSS explicitly define 'learning outcomes' in their documentation, Ecctis used the following categories of the documentation for comparison:

*Table 4: Learning outcomes for comparison of the DP and the CCSS and NGSS*

| **DP subject (group)** | **Categories used as learning outcomes** |
|---|---|
| *SCIENCES* | |
| biology | DP sciences subject group - aims and assessment objectives |
| chemistry | |
| physics | |
| *MATHEMATICS* | |
| mathematics: analysis and approaches | DP mathematics subject group - aims and assessment objectives |
| mathematics: applications and interpretation | |
| *ENGLISH* | |
| English A: language and literature | DP Studies in Language and Literature group – aims and assessment objectives |
| **CCSS and NGSS** | **Categories used as learning outcomes** |
| *SCIENCES* | |
| Physical Sciences (high school) | High school Physical Sciences standards<br>• HS-PS1 Matter and its Interactions<br>• HS-PS2 Motion and Stability: Forces and Interactions<br>• HS-PS3 Energy<br>• HS-PS4 Waves and their Applications in Technologies for Information Transfer[9] |
| Life Sciences (high school) | High school Life Sciences standards |

[6] International Baccalaureate. (2017). *What is an IB Education?*

[7] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards*.

[8] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*.

[9] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Topic arrangements of the NGSS.* https://www.nextgenscience.org/overview-topics

| | |
|---|---|
| | • HS-LS1 From Molecules to organisms: Structures and Processes<br>• HS-LS2 Ecosystems: Interactions, Energy, and Dynamics<br>• HS-LS3 Heredity: Inheritance and Variation of Traits<br>• HS-LS4 Biological Evolution: Unity and Diversity[10] |
| *MATHEMATICS* | |
| Mathematics (high school) | Standards for Mathematical Practice[11] |
| *ENGLISH* | |
| Common Core English Language Arts Standards grades 11/12 | English Language Arts Standards:[12]<br>• College and career readiness anchor standards for reading<br>• College and career readiness anchor standards for writing<br>• College and career readiness anchor standards for speaking and listening<br>• College and career readiness anchor standards for language |

Although not labelled as learning outcomes per se, the above categories were chosen as they were deemed to provide the most complete picture of the skills and knowledge that students should obtain upon completion of each subject.

For more information on the mapping process, see the Measuring Alignment section below.

## 3.2 Measuring Alignment (Similarities and Differences)

Alignment is a key concept for this series of studies. The aim of this study is to unpick the level of alignment between the DP and the CCSS and NGSS. Although Ecctis has sought to represent the alignment findings as straightforwardly as possible in this report, alignment is not a simple concept, so it is important to establish Ecctis' approach in this regard.

Alignment, as a term, is often used in education circles to refer to *internal* coherence between learning outcomes, assessment methods, teaching practices and other features of teaching and learning. This report does not consider *internal* alignment, but what might appropriately be labelled *external* alignment. Alignment of this type looks at the extent to which a programme (in this case, the DP) aligns with other educational programmes or standards (in this case, the CCSS and NGSS). This form of external alignment is particularly key to understand for an organisation like the IB which operates in so many international contexts, often alongside national curricula, where teachers and students may seek to move back and forth between IB and national streams of education.

[10] Ibid.
[11] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics. Standards for Mathematical Practice.* http://www.corestandards.org/Math/Practice/
[12] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. English Language Arts Standards*. http://www.corestandards.org/ELA-Literacy/ http://www.corestandards.org/ELA-Literacy/CCRA/R/

Within this narrower definition of *external* alignment, the idea is still broad and could be seen from any number of perspectives. In this series of studies, the IB has asked Ecctis to consider alignment from specific perspectives outlined by the RQs. The RQs thereby define the limits of the type of alignment that will be considered within the reports. Namely:

- At the programme level:
  - Alignment of philosophical underpinnings
  - Alignment of structure
  - Alignment of requirements and associated outcomes
  - Alignment of student learning pathways.

- At the subject level (in selected subjects):
  - Alignment of learning outcomes
  - Alignment of content
  - Alignment of demand.

To form a comprehensive picture of alignment, Ecctis' approach has used multiple repeating steps within each report. For the US, it sought to:

- Analyse to what extent the CCSS and NGSS have similarities with the DP.
- Analyse to what extent the CCSS and NGSS lack features contained within the DP.
- Analyse to what extent the DP lacks features contained within the CCSS and NGSS.

In this respect, **alignment is a measure of the extent to which there are similarities and differences between key selected criteria of two educational programmes**. High alignment indicates significant similarities, with few differences in key areas, whereas low alignment results from many differences in important aspects, with perhaps only few or non-impactful similarities. Alignment judgements in this study took a holistic view of similarities and differences and the likely impact these will have on what skills and knowledge students possess upon completion of a programme of study. As such, the study did not use fixed quantitative criteria to differentiate high from low alignment, but rather produced informed, holistic judgements drawing on an outcomes-focused perspective.

### Mapping

To accurately measure the alignment of the DP to the CCSS and NGSS, it is necessary to map the similarities and differences across the selected alignment criteria. This necessitates identification of the same structural features in the DP and in the CCSS and NGSS (the comparison points) so that a mapping process can be undertaken.

Mapping, in this case, refers to detailed analysis of a feature of an education programme (generally as represented within that programme's documentation). Specifically, mapping applies the same analytical method to two separate sets of data (for example, the learning outcomes of two different curricula), enabling similarities and differences between those two data sets to be understood through the different results of applying the same mapping method to both. Another important feature of mapping is that there is a paper trail of the analysis, as the approach is methodical, testable, and repeatable.

For more information on how mapping has been applied in this study, see sections 3.2.1 and 3.2.2.

## 3.2.1 Method: Programme-Level Comparison

Each aspect of the programme-level comparison is achieved through slightly different approaches to mapping and assessing alignment, the results of which inform the overall alignment evaluation. Each method is described in the appropriate subsection below.

### Philosophical Underpinnings

For the DP, the learner profile, the ATL, and the framework of international-mindedness were used to represent the philosophical underpinnings, while the CCSS's 'About the Standards'[13] and NGSS's 'Principles of the Framework' from the 'A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas' document[14] were used for the standards.

In order to carry out the comparative analysis, six themes were extracted from the DP's philosophical underpinnings:

*Table 5: Philosophical underpinning themes*

| **Philosophical underpinning themes** |
|---|
| • International outlook, diversity and intercultural understanding<br>• Grounded in real world contexts<br>• Principled and community-oriented<br>• Independence/self-management, critical inquiry and reasoning<br>• Communicative and collaborative competency<br>• Conceptual thought and understanding. |

This list of themes was mapped against both the DP's philosophical underpinnings and the philosophical underpinnings of the CCSS and NGSS to identify what aspects of the DP's philosophical underpinnings are shared with the comparison points and what aspects are unique to either the CCSS and NGSS's philosophical underpinnings or the DP's. The detail of this mapping was carried out in the mapping spreadsheets, while a visual summary and written explication of the findings can be found in the Philosophical Underpinnings section below (see section 4.2).

### Structure

Comparing the structures of the DP and a national programme or set of standards does not require a mapping process. Instead, subject offerings and the general structure of the qualification (including exit points, where applicable) can be represented with visuals for each programme or set of standards. These curriculum structure diagrams use block colours and simple box and arrow graphics to demonstrate structure and progression.

[13] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards.*
[14] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*.

Curriculum structure diagrams have been placed next to each other in this report to show the similarities and differences at a glance. The visual presentation is followed by a short write-up of the key similarities and differences, to maintain analytical focus on the alignment between the DP and the CCSS and NGSS.

#### Requirements and Associated Outcomes

The requirements and associated outcomes of each programme and/or set of standards are, like the structure, also simple, core features which do not require a mapping process in order to be compared. Comparisons and contrasts are drawn between the different requirements (e.g. entry requirements, pass/fail requirements, where applicable) linked to the comparison programmes and/or sets of standards, as well as associated outcomes (where applicable).

#### Student Learning Pathways

By ‘student learning pathways’, we refer to the learning route that each student can take through a programme – with focus on scope for subject-specific specialisation. A short textual write-up has been included to discuss how the CCSS and NGSS do not stipulate specific learning pathways (these are independently set by each signatory state), rendering comparison with the DP at this level impossible.

#### Assessment Methods

As the CCSS and NGSS do not constitute a full curriculum, they refrain from stipulating standards for assessment, with the latter being independently set by each signatory state. As a result, comparison with the DP at this level is not possible without state-to-state analysis – a short write-up providing further detail on this has been provided.

### 3.2.2 Method: Subject-Level Comparison

As previously described, a number of subjects has been selected by the IB for a closer look at alignment at the subject level. This includes a closer look at the learning outcomes for each subject, the subject content and the demand level. Each approach is outlined below.

#### Learning Outcomes

To analyse the alignment of learning outcomes at the subject level, the process began by extracting six to eight themes from the DP’s subject-level learning outcomes for each subject being analysed, encompassing both skills and knowledge areas. This thematic code was then mapped onto the learning outcomes of the DP subject and the comparison subject from the CCSS and NGSS.

The top-level results of the mapping process are represented with a table per subject area. Following the tables, a written commentary is provided regarding the presence of DP knowledge areas and skills (represented by themes) in the CCSS and NGSS and any knowledge areas and skills found in the CCSS and NGSS but not in DP.

#### Content

To compare the content of the DP subject and the comparison CCSS or NGSS subject, both are first presented next to each other in the document in a simple tabular format. Additionally, content mapping took place through a simple process of establishing whether each content sub-topic covered by the DP subject in question has 'clear alignment' with any content in the CCSS or NGSS comparison subject. The mapping spreadsheets demonstrate the full logic of all judgements.

A commentary is provided on DP subject content not found to have alignment points in the CCSS or NGSS subject and on CCSS and NGSS subject content topics not found to have alignment points in the DP subject.

### Demand

Comparing the demand of subject curricula is perhaps the most complex mapping and alignment analysis within this study. Ecctis' approach views demand from multiple perspectives to capture its relationship to skills as well as to the detail and scope of content.

To allow for a comprehensive assessment of the level of demand of the DP selected subjects against the respective comparison points, Ecctis has created a Demand Profile for each subject in the study. Each Demand Profile comprises four criteria designed to judge complexity, depth, breadth, workload levels and potential for intellectual stretch. These criteria have been applied uniformly across all subjects in the study, using an expert panel-approach (as outlined below).

*Demand Profile – Subject-level Judgement*

The Demand Profile is comprised of four scores (each between zero and three) based on specific criteria. Each score within each category has a specific definition which is listed in Appendix A. A panel of subject, teaching, and curriculum design experts analysed each subject curriculum and arrived at a consensus on which score descriptor in each category best matched with the curriculum in question. The categories which comprise the Demand Profile are as follows:

- **Revised Bloom's Cognitive Skills** score (0-3): this is an overall score of subject demand, based entirely on a review of learning outcomes. Levels have been defined based on increasing emphasis of higher order cognitive skills taken from Bloom's Revised Taxonomy.[15]

- **Depth of Knowledge** (adapted from Webb's) score (0-3): this is an overall score evaluating the depth of knowledge or complexity of knowledge and skills required by curriculum standards and expectations. The score is focused on subject content and learning outcomes, complemented by assessment where relevant/possible. Levels have been defined based on the depth of detail studied per topic, as well as the depth of thinking described in Webb's Depth of Knowledge framework.[16]

- **Volume of Work** score (0-3): this is a trifactor score, considering:
    a. breadth of content – i.e. how many topic and sub-topics are covered

[15] Krathwohl, D. (2002). A Revision of *Bloom's taxonomy: An Overview.* Theory Into Practice, Vol 41(4). Available from: www.tandfonline.com/doi/abs/10.1207/s15430421tip4104_2?journalCode=htip20

[16] Webb, N. L. (2002). *Depth-of-knowledge levels for four content areas*. Language Arts. http://ossucurr.pbworks.com/w/file/fetch/49691156/Norm%20web%20dok%20by%20subject%20area.pdf

b. depth of content – i.e. the extent to which the topics and sub-topics are focused upon, amplified and explored.[17]

c. specified timeframe – i.e. the time allocated for studying the subject.

The three factors – breadth, depth, and time – were all considered in defining the levels.

- **Outstanding Areas of Subject Demand** score (0-3): this score reflects the number of content areas viewed as more challenging and/or conducive to intellectual stretching of students. Levels have been defined on a scale of increasing number of 'stretch areas'.

*Demand Panel: Expert Judgement Procedure*

Demand analysis and judgements against the above criteria rested with a panel of experts comprised of both curriculum and teaching experts – i.e. international education researchers experienced in comparative secondary curriculum evaluation – and subject experts – i.e. researchers and consultants with a subject specialism in the relevant subject areas. For both expert types, teaching experience, understanding of appropriate national/international teaching contexts, and experience of curriculum and learning outcomes comparisons were prioritised.[18]

For the panels discussing the demand level of the DP subjects and respective comparison subjects in the CCSS and NGSS, VCE, and OSSD reports, the composition of each panel was as follows:

[17] Note: 'depth of content' primarily describes what is on the curriculum (i.e. the level of detail comprised in each topic), whereas 'depth of knowledge' describes what the students need to be able to do (i.e. how complex and extensive the thinking processes involved are).

[18] To minimise potential biases and subjectivity, Ecctis' recruitment procedure excluded candidates with experience of teaching any of the comparison qualifications in this study.

*Figure 1: Demand panels details*

**Mathematics panel**

**Length**: one day
**Preparation time**: four days per panellist
**Format**: remote
**Number of subjects discussed:** 18
**Number of panellists**: 6

**Composition:**

- two Mathematics experts with experience teaching across multiple education systems
- two Mathematics experts with experience teaching upper secondary Mathematics in the UK
- two curriculum experts with a background in learning outcomes analysis and teaching at higher education level

**Science panel**

**Length**: one day
**Preparation time**: four days per panellist
**Format**: remote
**Number of subjects discussed**: 12
**Number of panellists**: 6

**Composition**:

- three STEM experts with experience teaching across multiple education systems
- two curriculum experts with a background in learning outcomes analysis and teaching at higher education level
- one curriculum review expert with a background in analysis and management of upper secondary and higher education projects.

**Humanities (History and English) panel**

**Length**: half day
**Preparation time**: three days per panellist
**Format**: remote
**Number of subjects discussed:** 6
**Number of panellists**: 8

**Composition**:

- one History expert with a background in teaching at higher education level and learning outcomes analysis
- one History expert with a background in teaching upper secondary History in the UK
- two English experts with experience teaching across multiple education systems
- one English language expert with a background in teaching upper secondary English Literature in the UK
- one Languages expert with a background in curriculum review in upper secondary and higher education projects
- two curriculum experts with a background in learning outcomes analysis and teaching experience at secondary and higher education levels.

All panellists were provided with the relevant extracts from the appropriate qualifications' specifications, including (where available):

- Learning outcomes and aims of the qualification
- Assessment structure
- Information about guided learning hours or curriculum time
- Assessment objectives
- Content.

The experts were also provided with a document containing:

- An introduction to the comparative analysis task
- Descriptions of the demand taxonomies
- The demands instrument (used to record findings).

Panellists conducted between three and four days of panel preparation, reviewing the appropriate curriculum documentation in detail and scoring each subject against the demand criteria provided (the template utilised for this has been included in Appendix C). Following this preparation, participants then took part in their respective panels, which were all hosted remotely on Microsoft Teams. Both the Mathematics and Science demand panels lasted one full working day, while the Humanities (History and English) panel lasted for half a day due to the lower number of subjects being discussed.

All judgements resulted in scores from 0-3 for each demand criterion mentioned above, with each score for each criterion being pulled into each course's demand profile. The panel approach was used to debate the findings and scores reached by each member of the panel and arrive at an evidence-based consensus on every demand score for every subject.[19]

Visually, each demand profile is represented by radar diagrams to facilitate demand comparison between subjects.

NB: all demand scores produced should be interpreted as approximate judgements given the varying degrees of documentation and detail available for each curriculum, as well as likely variation on how the curricula are implemented in practice.

[19] Note: each score was debated by the panel until a unanimous agreement was reached.

# 4. Programme-Level Alignment

This section offers top-level overviews of the DP, the CCSS and the NGSS, as well as the findings from the programme-level comparative analysis undertaken between the DP and both sets of standards reviewed in this study (CCSS and NGSS).

## 4.1 Programme Overviews

### 4.1.1 The International Baccalaureate Diploma Programme

The DP was established in 1968 as a two-year pre-university programme for 16-19-year-old students.[20]

Students who aim to achieve the Diploma award must select one subject from each of the six subject groups:

- Studies in language and literature
- Language acquisition
- Individuals and societies
- Sciences
- Mathematics
- The arts.[21]

Students who do not wish to take a subject from the arts subject group may opt to study an additional sciences, individuals and societies, or languages subject instead.

All subjects are studied concurrently over the two-year duration. Most subjects can be taken at either HL or SL. In terms of teaching hours, the DP's documentation recommends 150 teaching hours for individual subjects at SL and 240 teaching hours are at HL.[22]

In addition to the six subjects taken from these groups, DP students will also need to complete three further curriculum components. Theory of knowledge (TOK) allows students to reflect on the nature of knowledge by considering their subjects from a broader perspective.[23] The extended essay is a self-directed piece of research which results in a 4000-word essay.[24] Creativity, activity, service (CAS) is not formally assessed but requires that students undertake a creative endeavour, take part in something physically active, and participate in a voluntary or unpaid activity.[25] Together, these three components comprise the DP 'core'.

[20] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 5.
[21] International Baccalaureate. (2021). *Curriculum*.
[22] Ibid.
[23] International Baccalaureate. (2021). *Theory of knowledge*. https://www.ibo.org/programmes/diploma-programme/curriculum/theory-of-knowledge/
[24] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 2.
[25] International Baccalaureate. (2021). *CAS projects.* https://www.ibo.org/programmes/diploma-programme/curriculum/creativity-activity-and-service/cas-projects/

To achieve the DP a student must take at least three HL subjects.[26] The maximum number of subjects that can be taken at higher level is four. HL subjects are intended to prepare learners for the discipline specialisation of higher education, whilst the SL subjects balance this by broadening the range of subjects studied.[27]

The DP curriculum framework is based on a concentric circle model (see below), whereby the learner profile is positioned at the centre to represent its relevance to all aspects of the programme. The next circle comprises the 'core' requirements of TOK, the extended essay, and CAS. The six subject groups are then encircled by international-mindedness and the programme title – indicating that everything students study is unified by the underpinning philosophy of encouraging thinking from a perspective that embraces other points of view outside one's own frame of reference.[28]

*Figure 2: IB Diploma Programme curriculum model*[29]


Both internal and external assessment methods are used in the DP. In most subjects, written examinations are taken at the end of the programme and are marked by external IB examiners. Internally assessed tasks normally comprise between 20-30% of the total mark in each subject.[30,]

[26] International Baccalaureate. (2021). *Curriculum*.
[27] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 6.
[28] International Baccalaureate. (2021). *Curriculum*.
[29] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 2.
[30] International Baccalaureate. (2021). *Understanding DP assessment*. https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/understanding-ib-assessment/; International Baccalaureate. (2014). *International Baccalaureate Diploma Programme: A guide to assessment*. p. 3.

Question types used in DP assessment vary from subject to subject. Essays, structured problems, short-response questions, data-response questions, case-study questions, and multiple-choice questions are some of the external assessment question types deployed.[31] Coursework forms part of the assessment for areas of the DP such as the extended essay and TOK.[32] This is normally carried out over an extended period under teacher supervision. Where students complete internally assessed tasks, these are marked by teachers and moderated by the IB.[33] Some of the internal assessment methods used include oral work in languages, fieldwork in geography, laboratory work in the sciences, and artistic performances.[34]

Each DP subject, whether taken at HL or SL, is graded from 1-7 (with 7 representing the highest achievement level).[35] If a student has taken enough subjects at the correct level to be in contention for the Diploma award, a minimum of 24 points is needed to achieve the qualification. A minimum grade of 3 is also needed in at least four subjects to achieve the qualification.[36]

Additionally, 42 points are available from the combination of the grades for six subjects and a further three points are available to students for successful completion of the 'core' elements of TOK, the extended essay and CAS. The TOK and extended essay components of the DP are each marked on an A-E scale, where an A grade is the highest award, and an E grade the lowest.[37] Their combined results can contribute up to three additional numerical points to the overall DP score (see Table 6 below). CAS does not constitute a graded part of the DP, although its completion is mandatory to receive the award of the Diploma.

HL and SL subjects are assessed against the same grade descriptors;[38] however, HL candidates are expected to demonstrate the various elements of the grade descriptors across a greater range of knowledge, skills, and understanding.

A bilingual Diploma is awarded to students who achieve:

- Grade 3 or higher in two language subjects from subject group 1, or,
- Grade 3 or higher in a group 1 language subject and a grade 3 or higher in a group 3 or 4 subject taken in a different language.

Certificates are awarded to students that have taken individual subjects but not enrolled on the full Diploma, or DP candidates who do not complete the full DP.[39] Prospective candidates can enrol in as many individual subjects as permitted by their school; these are graded with the same 1-7 system used in the full DP.

---

[31] International Baccalaureate. (2021). *Assessment and Exams*. https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/
[32] International Baccalaureate. (2021). *Understanding DP Assessment*.
[33] Ibid.
[34] International Baccalaureate. (2021). *Assessment and Exams*.
[35] International Baccalaureate. (2021). *Understanding DP Assessment*.
[36] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 4.
[37] Ibid.
[38] International Baccalaureate. (2021). *Understanding DP Assessment*.
[39] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 4.

*Table 6: Letter-grade: numerical score conversion matrix*[40]

<table>
<tr><th></th><th></th><th colspan="5">Theory of knowledge (TOK)</th></tr>
<tr><th></th><th>Grade awarded</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><th rowspan="5">The extended essay</th><td>A</td><td>3</td><td>3</td><td>2</td><td>2</td><td rowspan="4">Failing condition</td></tr>
<tr><td>B</td><td>3</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>C</td><td>2</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>D</td><td>2</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>E</td><td colspan="5">Failing condition</td></tr>
</table>

No formal entrance requirements are stipulated as the IB envisages numerous educational pathways leading to the DP.[41] However, the IB recommends consulting the subject guides prior to enrolment to ensure an adequate understanding of programme expectations.[42]

### 4.1.2 Standards

#### Common Core State Standards

The CCSS are a set of college and career ready standards designed to ensure that students of high-school graduation age are prepared for their progression either into higher education or the workforce. The standards outline basic skills and knowledge that students should have gained by each grade level, from kindergarten through to grade 12, in English language, arts/literacy, and mathematics. 43 states have currently adopted these standards.[43]

The standards were developed by the National Governors Association (NGA) Centre for Best Practices and the Council of Chief State School Officers (CCSSO), with input from educators, students, administrators, parents and experts from across the US. The standards intend to promote equity and collaboration among states to ensure consistency in education. As such, the CCSS promote standardisation and provision of:

- Teaching materials such as textbooks and media.
- Comprehensive assessment system implementation and development to measure student performance.
- Support for institutions and students in meeting the standards.[44]

Notably, the standards do not dictate teaching methods or curriculum design, but rather set out goals upon which teachers are to devise their curriculum and lesson plans, allowing for flexibility and tailored delivery. The standards impact teachers by:

- Providing consistent goals and benchmarks for teachers to base their curriculum and lessons on, ensuring students' progress with the skills needed for the next steps in their academic or professional careers.

[40] International Baccalaureate. (2017). *Assessment principles and practices: Quality assessments in a digital age*. p. 220.
[41] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 22.
[42] Ibid.
[43] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. Frequently Asked Questions.* http://www.corestandards.org/wp-content/uploads/FAQs.pdf
[44] Ibid.

- Providing consistent expectations for students who move between states or districts, allowing for an easier transition in the education system.
- Providing the opportunity to collaborate with teachers across the country in the development of curricula, materials, and assessments.
- Helping with teacher education in preparation for beginning a career.[45]

The implementation of the standards is decided at state and local levels, allowing for flexibility and different approaches of their implementation alongside any other state-specific goals.[46]

The standards set out several critical content topics to be covered (see table below), with remaining content decisions being made at state and local levels. In addition to these outlined subject areas, students are expected to systematically acquire knowledge via a range of activities by reading, writing, speaking, and listening, and to apply mathematical concepts to real-world issues and challenges.[47]

*Table 7: Overview of critical content*

| Critical content | |
|---|---|
| **English Language Arts** | **Mathematics** |
| • Classical myths and stories from around the world<br>• America's founding documents<br>• Foundational American literature<br>• Shakespeare | • Whole numbers<br>• Addition<br>• Subtraction<br>• Multiplication<br>• Division<br>• Fractions<br>• Decimals |

The CCSS provide a list of sample texts varying in difficulty that teachers can refer to when tailoring English Language Arts lessons to different age groups, but no compulsory texts are prescribed. For mathematics, the discipline is standardised to a progressive sequencing of teaching, so that mathematical concepts are introduced at consistent age groups across states, allowing progression by grade level and ensuring coherency at an internationally competitive level.[48]

### Next Generation Science Standards

The NGSS are a set of standards, developed in 2013, outlining the scientific and engineering practices, crosscutting concepts, and core ideas within science that all K-12 students' education should be tailored around in applicable states.[49] They were developed with the intention of aligning current scientific curriculum demands with more contemporary understandings of science, and modern understandings of best teaching practice.[50]

---

[45] Ibid.
[46] Ibid
[47] Ibid.
[48] Ibid.
[49] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Developing the Standards.* https://www.nextgenscience.org/developing-standards/developing-standards
[50] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Factsheet.* https://www.nextgenscience.org/sites/default/files/resource/files/NGSSFactSheet2016revised.pdf

The NGSS were developed in a collaborative, state-led process by science supervisors from 26 states, consulting teachers, scientists, and education workers, who drafted the standards based on the National Research Council's document 'A Framework for K-12 Science Education'.[51] Rigorous feedback by a large and varied review committee across the 26 states contributed to the refinement of the NGSS. The standards were benchmarked against countries renowned for strong student performance in science and engineering fields, including Finland, South Korea, China, Canada, England, Hungary, Ireland, Japan, and Singapore. This aimed to ensure that students leave secondary education with a science education that is comprehensive and internationally competitive.

### Assessment Methods

While the CCSS and NGSS unite the states that have signed up to them around key expectations for the skills and knowledge students should acquire by the end of each grade, the means of assessment – i.e. modes, types, frequency – are independently defined by each state.

Nevertheless, two state-led consortia have formed to work on developing new assessment systems in line with the CCSS: the Partnership for Assessment of Readiness of College and Careers (PARCC)[52] and the Smarter Balanced Assessment Consortium (SBAC).[53] According to CCSS documentation, most states have chosen to take part in one of the above consortia, indicating a desire to move towards a more harmonised assessment system in future.

### Design Principles for CCSS

As articulated in the 'About the Standards' section of the CCSS website, the CCSS standards have been developed to tackle a reported stagnation in academic progress by US-based students and bring their learning back on par with international best practices. To do so, the standards have been designed to be:

1. Research- and evidence-based
2. Clear, understandable, and consistent
3. Aligned with college and career expectations
4. Based on rigorous content and application of knowledge through higher-order thinking skills
5. Built upon the strengths and lessons of current state standards
6. Informed by other top performing countries in order to prepare all students for success in our global economy and society.[54]

As can be ascertained from the above list, a key focus of the standards is to ensure that students acquire the relevant knowledge and develop the necessary higher-order thinking competencies to be successful when entering the 'global economy and society'.[55]

[51] National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*.
[52] District of Columbia. The Partnership for Assessment of Readiness for College and Careers (PARCC). https://osse.dc.gov/parcc
[53] Smarter Balanced Assessment Consortium (SBAC). https://smarterbalanced.org/
[54] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards.*
[55] *Ibid.*

Whilst the CCSS cover the topics previously stated, there is a separate – though interlinked – set of standards relating to science.

### Design Principles for NGSS

Overall, the NGSS promote 'student-centred' learning that encourages collaboration, communication, and problem solving.[56] The standards propose five innovations for teaching, designed to enhance the quality of content and learning when delivering science education (see table below).

*Table 8: Five innovations for teaching developed within the NGSS.[57]*

| Innovations for teaching | |
|---|---|
| Three-dimensional learning | There are three equally important, distinct dimensions to learning science included in the NGSS: Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The NGSS connect all three dimensions. To prepare students for success in college and 21st century careers, the NGSS also connect scientific principles to real-world situations, allowing for more engaging and relevant instruction to explore complicated topics. |
| All three dimensions build coherent learning progressions | The NGSS provide students with continued opportunities to engage in and develop a deeper understanding of each of the three dimensions of science. Building on the knowledge and skills gained from each grade – from elementary through high school – students have multiple opportunities to revisit and expand their understanding of all three dimensions by the end of high school. |
| Students engage with phenomena and design solutions | In instructional systems aligned to the NGSS, the goal of instruction is for students to be able to explain real-world phenomena and to design solutions using their understanding of the Disciplinary Core Ideas. Students can achieve this goal by engaging in the Science and Engineering Practices and applying the Crosscutting Concepts. |
| Engineering and the Nature of Science is integrated into science | Some unique aspects of engineering (e.g., identifying problems) are incorporated throughout the NGSS. In addition, unique aspects of the nature of science (e.g. how theories are developed) are also included throughout the NGSS as practices and crosscutting concepts. |
| Science is connected to math and literacy | The NGSS not only provide for coherence in science instruction and learning but the standards also connect science with mathematics and English Language Arts. This meaningful and substantive overlapping of skills and knowledge affords all students equitable access to the learning standards. |

As can be ascertained from the above table, the standards prioritise the development of students who are prepared to enter university and the 21st-century workforce. It does so particularly by emphasising linkages and connections between the scientific disciplines taught and the real world, building students' ability to engage with the latter and design solutions for real-world situations.

### Consistency with the Common Core State Standards for Mathematics

Whilst the NGSS and the CCSS are separate frameworks, there are some links between the standards. The development of the NGSS incorporated some of the development team for the Common Core State Standards for Mathematics (CCSSM) to ensure equivalence across subjects and alignment of skill expectations per grade, including the development of NGSS-

---

[56] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Factsheet.*
[57] Ibid.

aligned teaching materials and assessments. As many mathematical and scientific concepts are cross-subject, such as statistical analysis and algebra, the NGSS have been developed with reference to the CCSSM, to deliver these concepts consistently alongside mathematics learning, ensuring that neither subject outpaces the other.[58]

[58] Appendix L – Connections to the Common Core State Standards for Mathematics. Accessed via https://www.nextgenscience.org/sites/default/files/Appendix-L_CCSS%20Math%20Connections%2006_03_13.pdf

## 4.2 Philosophical Underpinnings

*Figure 3: Philosophical underpinnings comparative analysis diagram for the DP and CCSS*

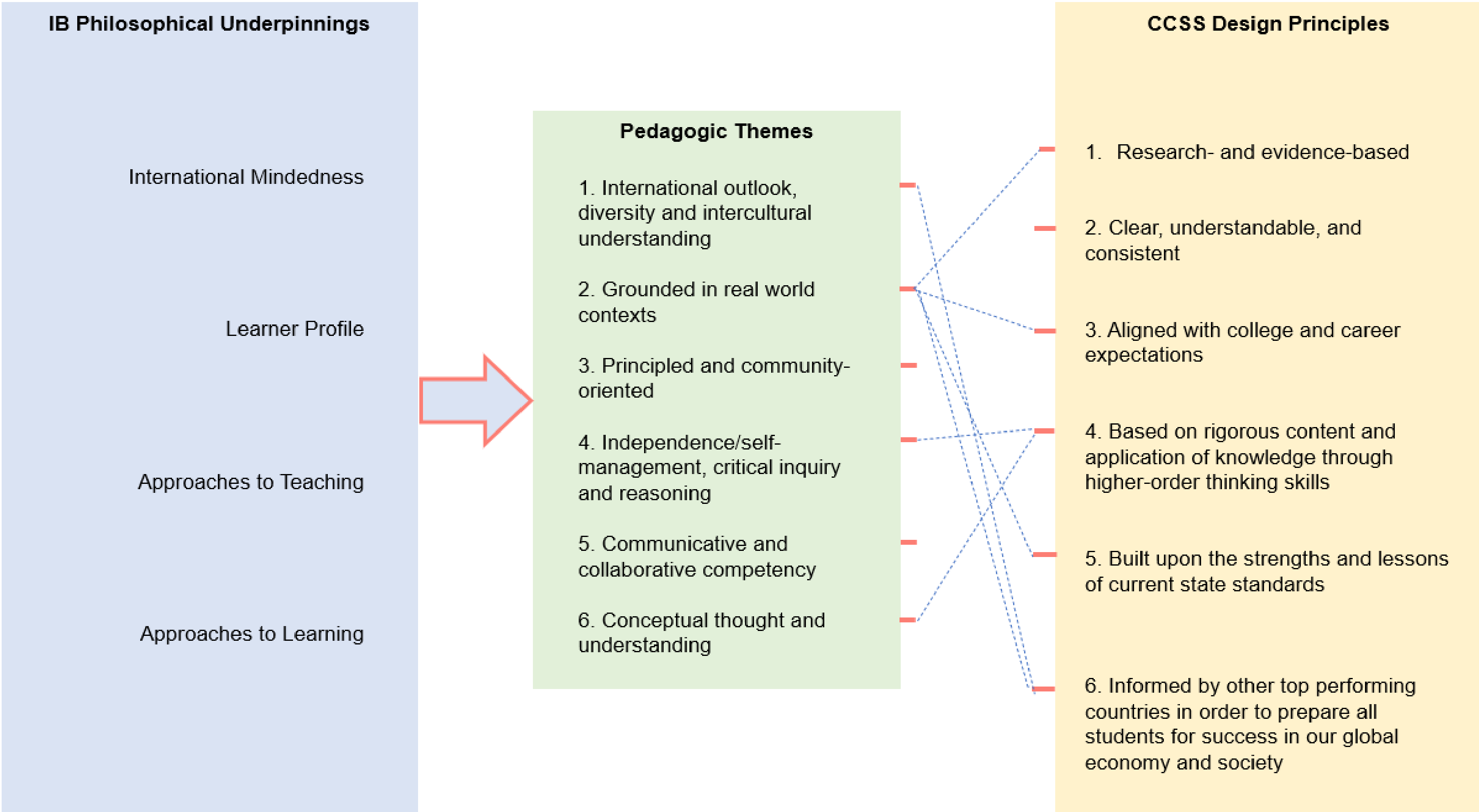
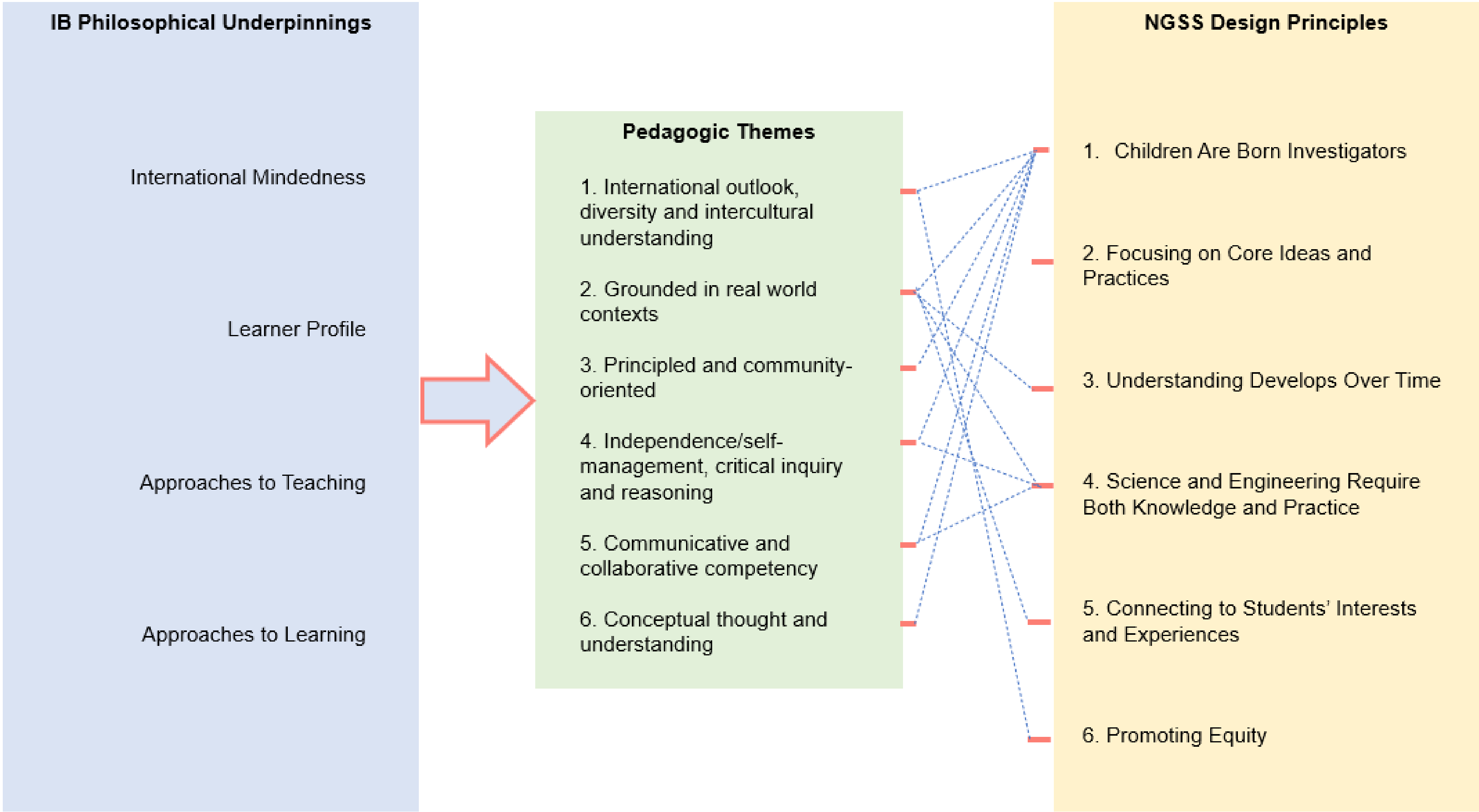


*Figure 4: Philosophical underpinnings comparative analysis diagram for the DP and NGSS*



The IB learner profile, which is used across all IB programmes, including the DP, outlines ten attributes that all students should strive towards.[59] Linked to these attributes, there are five categories of approaches to learning skills that all IB programmes aim to develop as well as six categories of approaches to teaching principles. The table in Appendix B presents these qualities of the IB's underpinning philosophies along with the overview used in IB documentation to describe the quality of international-mindedness that also encircles all IB teaching and learning.

The six themes identified within the IB literature have relatively consistent presence across all component parts (learner profile, ATL, and international-mindedness). As a result, these themes present a 'boiled-down' version of the DP's philosophical underpinnings.

*Table 9: Philosophical underpinning themes*

| **Philosophical underpinning themes** |
| --- |
| • International outlook, diversity and intercultural understanding<br>• Grounded in real world contexts<br>• Principled and community-oriented<br>• Independence/self-management, critical inquiry and reasoning<br>• Communicative and collaborative competency<br>• Conceptual thought and understanding |

To identify the level of alignment in relation to the philosophical underpinnings between the DP and the CCSS and NGSS, the project team mapped the philosophical underpinnings of the CCSS and NGSS against these six themes extracted from the DP's philosophical underpinnings.

When mapping the six DP themes onto the CCSS and NGSS design principles – and despite the considerably lesser extent to which philosophical underpinnings are articulated in the CCSS and NGSS documentation available – the majority of DP themes was nevertheless still found to be somewhat present in the frameworks.

For example, the CCSS show some presence of 'conceptual thought and understanding' and 'critical inquiry and reasoning' highlighted in the DP themes – in that they explicitly state that the standards are 'Based on rigorous content and the application of knowledge through higher-order thinking skills'. The 'International outlook, diversity and intercultural understanding' theme is also present to some extent, with the standards being 'Informed by other top performing countries in order to prepare all students for success in our global economy and society'. However, the CCSS pedagogical emphasis here seems to be mostly placed on student success, as opposed to the DP's active promotion of diversity and equity as principles. Some references to the 'Grounded in real world contexts' DP theme may also be implied through the 'Research and evidence-based', 'Aligned with college and career expectations' and 'Informed by top-performing countries to prepare all students for success in our global economy and society' CCSS principles, though, given the vagueness of the latter, it is unclear whether the CCSS share the same conceptualisation of 'real world contexts' as the DP.

[59] International Baccalaureate. (2017). *What is an IB education?*

Notably, both the ‘Principled and community-oriented’ and ‘communicative and collaborative competency’ themes were found to be absent from the CCSS text.[60]

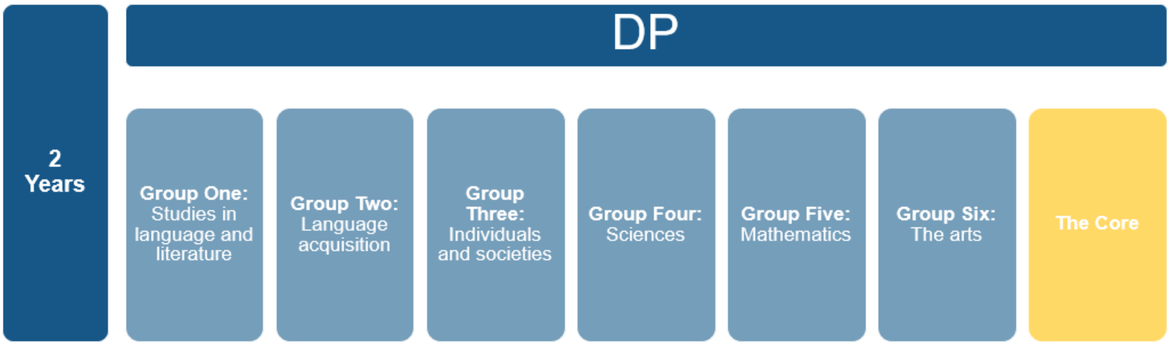
In the NGSS, reference to all the DP’s philosophical underpinnings’ themes was found to at least some extent within the NGSS’s documentation. In particular, all the DP themes were found within the NGSS’s ‘Children are born investigators’ section, while the ‘Science and engineering require both knowledge and practice’ section was found to incorporate three of the six DP themes – i.e. ‘Grounded in real world contexts’, ‘Independence/self-management, critical inquiry and reasoning’, and ‘communicative and collaborative competency’.

Overall, the philosophical underpinnings of the CCSS are less aligned with those of the DP than those of the NGSS, with the latter encompassing all DP themes and the former only a few. Nevertheless, as neither the CCSS nor the NGSS constitute a programme of study, the level of alignment is likely to vary in line with implementation on a state-by-state basis.

## 4.3 Structure

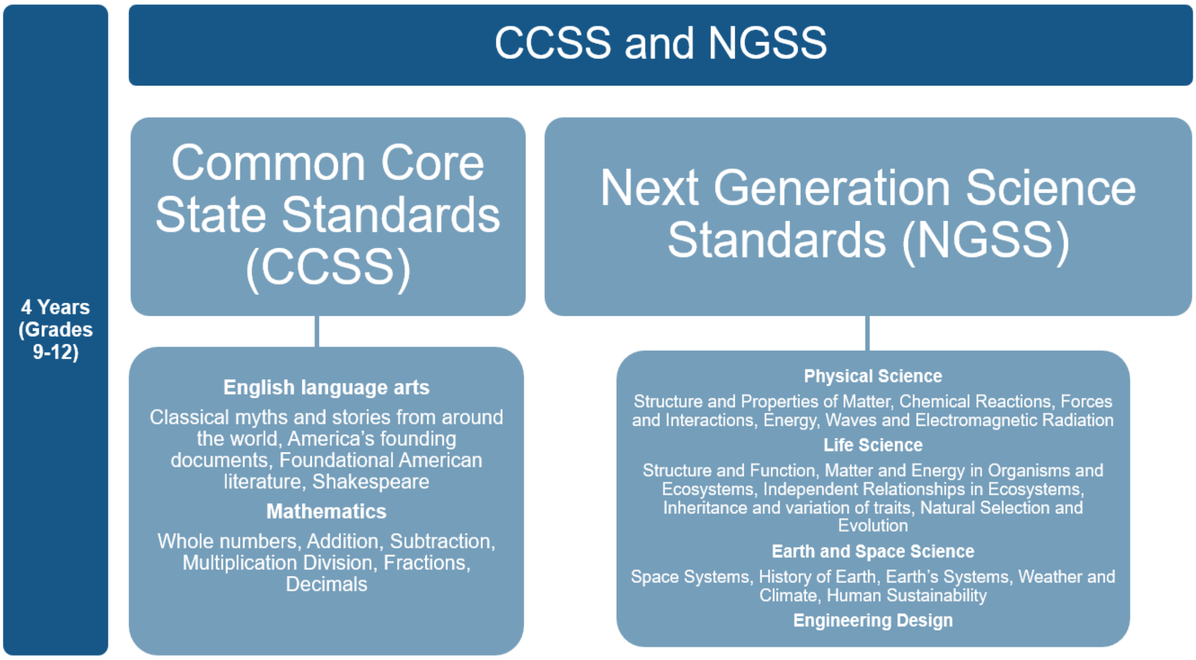
There are six subject groups comprising the DP and students pursuing the Diploma award are required to select one subject from each of the six groups.[46] Similarly to the DP, the CCSS organise their subjects in thematic categories based on the critical content of each subject. These two thematic categories are English Language Arts and Mathematics. Additionally, the NGSS are structured around three distinct dimensions to learning science including Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The NGSS connect all three dimensions. The NGSS also organise the subjects in subject categories. These thematic categories include Physical Sciences, Life Sciences, Earth and Space Sciences and Engineering Design. According to the framework documentation, the NGSS are aligned, by grade level and cognitive demand with the CCSS English Language Arts and Mathematics , ensuring an aligned sequence of learning in all content areas. The CCSS for English Language Arts and Mathematics and the NGSS overlap and are reinforcing.

*Figure 5: Structural overview of the DP*




[60] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards.*

*Figure 6: Structural overview of CCSS and NGSS*




As can be seen above, both the DP and the CCSS and NGSS cover the broad subject areas of languages, mathematics and science.

As the DP is a full curriculum design, it also features many components not present within the CCSS and NGSS, including subjects which fall outside the remit of those standards. However, such subjects are often part of the US high school curriculum at state level, and each state is responsible for designing and implementing these subjects.[61]

The standards do not contain the SL/HL differentiation contained within the structure of the DP, as the standards are meant to apply to all relevant high school-level subject courses regardless of level. Nor do the standards provide requirements of how students might carry out inter-subject activities, as the DP does with its 'core' components of CAS, TOK, and the extended essay.

## 4.4 Requirements and Associated Outcomes

In terms of entry requirements, there are no formal requirements stipulated for the DP, as the IB envisages numerous educational pathways leading to upper secondary education.[62] However, the IB recommends consulting the subject guides prior to enrolment to ensure an adequate understanding of programme expectations.[63] As they do not constitute a full programme of study, the CCSS and the NGSS also do not stipulate entry requirements for any qualification designed to meet the standards – there is simply an expectation that students will have completed their education up to grade 9.

[61] California Department of Education. (2022). *Curriculum & Instruction Subject Areas.* https://www.cde.ca.gov/ci/cr/cf/cimegasubjectareas.asp
[62] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 22.
[63] Ibid.

Regarding associated outcomes, both the DP and the CCSS and NGSS are designed to prepare students for higher education or employment.

## 4.5 Student Learning Pathways

In the CCSS, students progressing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings. The English college and career anchor standards and high school grade-specific standards work in tandem to define college and career readiness expectations – the former providing broad standards, the latter providing additional specificity. There are College and Career Standards for each one of the content areas of the CCSS in English Language Arts, providing detailed descriptions of the knowledge and skills that students must demonstrate in K-12 as they are progressing through their studies.[64]

For the CCSSM, the discipline is standardised to a progressive sequencing of teaching, so that mathematical concepts are introduced at consistent age groups across states, allowing progression by grade level and ensuring coherency at an internationally competitive level.[65] Similarly, the NGSS provide students with continued opportunities to engage in and develop a deeper understanding of each of the three dimensions of science. Building on the knowledge and skills gained from each grade – from elementary through high school – students have multiple opportunities to revisit and expand their understanding of all three dimensions by the end of high school.[66] Like the CCSS and the NGSS, the DP provides detailed descriptions of the knowledge and skills that students need to acquire as they progress in their studies.

Regarding the degree of specialisation available to students, the DP has a clear pattern for all students, whereby subject groups enable specific choices that match the student's interests while maintaining the overall breadth of a baccalaureate-style programme. As the standards are not a full curriculum, comparison at this level is not possible and would require state-by-state analysis.

## 4.6 Assessment Methods

As mentioned in the programme overviews at the top of this section, the CCSS and NGSS do not constitute a full curriculum, but rather set expectations around key skills and knowledge that students should obtain at the end of each grade. As a result, the means of assessment are not stipulated in the standards – they are independently defined by each state, with considerable differences in how implementation takes place.

This being the case, it is not possible to meaningfully compare the DP and the CCSS and NGSS when it comes to assessment without conducting state-by-state analysis. The way assessment is implemented by signatory states – e.g. its frequency, modes, types, questions used – differs significantly across states.

---

[64] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. English Language Arts Standards.*
[65] Ibid.
[66] Ibid.

# 5. Subject-Level Alignment

This section focuses on answering RQs 1, 2 and 3 and the sub-questions associated to it, namely:

*Table 10: Research questions*

| |
|---|
| **RQ1:** To what degree do DP English and mathematics curricula align with the CCSS for grades 11 and 12?<br>1.1: In what way are DP curricula and the CCSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and in which areas do they not meet the expectations of the CCSS?<br>1.2: How do DP expected learning outcomes compare with the CCSS in terms of demand and difficulty?<br><br>**RQ2**: To what degree do the DP science curricula align with the NGSS for grades 11 and 12?<br>2.1: In what way are DP curricula and the NGSS similar and in what way are they different? In which areas do the DP curricula exceed the expectations and which areas do they not meet the expectations of the NGSS?<br>2.2: How do DP expected learning outcomes compare with the NGSS in terms of demand and difficulty?<br><br>**RQ3**: How do DP curricula compare with the CCSS/NGSS in regard to:<br>3.1: Content<br>• Structure<br>• Topics (including relationship among topics and progression of content).<br>3.2: Expected learning outcomes<br>• Knowledge<br>• Competencies (subject-specific skills, college and career readiness competencies, including learning progressions) |

For each subject area, this section briefly introduces the subjects being compared, followed by an overview of the findings from the comparative analysis between the DP subjects and the comparison points regarding learning outcomes, content and demand.

## 5.1 English

Below is the list of subjects used in the English subject comparison analysis.

**English A: language and literature**[67]
English A: language and literature (English LL) is a subject offered within the DP Language and literature subject group. This subject introduces the critical study and interpretation of written and spoken texts from a wide range of literary forms and non-literary text-types**.** The subject is available at SL and HL, with HL requiring study of a greater number of literary works and non-literary texts, additional written guided analysis in paper 1, and a fourth assessment component in the form of an essay.

[67] International Baccalaureate. (2015). *Language A: language and literature.* p.7.

**Common Core State Standards: English Language Arts Standards**[68]
Within the CCSS are the English Language Arts standards, which cover all grades K-12. The analysis focuses on standards specified as being for grades 11-12. The standards are not a curriculum but reflect what students should be able to understand and do by the end of high school and aim to prepare students for college and future careers. The College and Career Readiness Anchor Standards describe the core knowledge and skills to be developed and are complemented by specific standards for each grade.

### 5.1.1 Learning Outcomes – English

This section compares and contrasts the English LL learning outcomes with the CCSS English.

For the DP English LL course, this study used the ‘studies in Language and Literature’ group aims, as well as the ‘assessment objectives’ in the DP English LL syllabus. For the CCSS, the learning outcomes were extracted from the ‘College and Career Readiness Anchor for Reading’, ‘College and Career Readiness Anchor for Speaking and Listening’, ‘College and Career Readiness Anchor for Writing’ and ‘College and Career Readiness Anchor for Language’ sections of the standards.

The following table demonstrates the learning outcome themes that were extracted from English LL outcomes and indicates if and where they were judged to have presence within the CCSS.

*Table 11: Presence of the DP English A: language and literature learning outcome themes in the CCSS anchor standards*

| Themes extracted from DP English LL learning outcomes | Presence in the CCSS | |
|---|---|---|
| Developing knowledge of a wide range of diverse texts and forms | | Present across the anchor standards for Reading, Writing, and Listening |
| Understanding the relationship between context and text | | Somewhat present, mostly demonstrated by anchor standards for Language |
| Extracting meaning and interpreting a text | | Present across the anchor standards for Reading, Writing, and Listening |
| Understanding the writer’s craft | | Present across the anchor standards for Reading, Writing, Listening, and Language |
| Formulating and expressing ideas in a variety of ways | | Present across the anchor standards for Writing, Listening, and Language |
| Developing appreciation of intertextuality and interdisciplinarity | | Implicitly present across the anchor standards for Reading and Writing |

[68] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. English Language Arts Standards.*

| | | |
|---|---|---|
| Developing an identity as a reader of English | | Implicitly present across the anchor standards for Reading, Writing, Listening, and Language |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *This theme is well-evidenced in the learning outcomes of the CCSS.* | | *This theme is partially evidenced in the learning outcomes of the CCSS.* | | *This theme is not evident in the learning outcomes of the CCSS.* |

*<u>Presence of the DP's Learning Outcome Themes</u>*

Many of the themes within DP English LL's learning outcomes are present within the CCSS English Language Arts anchor standards. Both require students to develop their understanding of a diverse and varied range of texts and forms. They also both outline the requirement for understanding technical aspects of the writer's craft alongside how readers can extract meaning using analysis, interpretation, and evaluation. Both require students to formulate and express ideas for a range of purposes, tasks and audiences.

Students of DP English LL are expected to develop an appreciation of intertextuality and interdisciplinarity. Students within the CCSS English programme are expected to develop cultural capital within studies of other subjects, transferring this across to textual interpretation. There is no explicit expectation that they understand and explore this process. Likewise, students must navigate 'digital texts and physical texts', although they are not required to explore the relationship between the two forms. Therefore, DP English LL students will cover interdisciplinarity and intertextuality explicitly, whereas CCSS students may do incidentally and aren't expected to understand these two concepts.

DP English LL expects students to understand the relationship between a range of different contexts and different texts. Beyond the language anchor standards, where students explore 'how language functions in different contexts', students following the CCSS are not expected to explore an extensive variety of contexts or their explicit relationship to a text. For example, the Reading strand of anchor standards requires students to only 'assess how point of view […] shapes' a text.

DP English LL contains various aims requiring students to develop an identity within English; fostering a 'lifelong love' of the subject and understanding of 'perspectives on human concerns'. Insofar as an identity within English is constituted of literary skills, the CCSS for English could be said to have similar aims. However, the CCSS for English are not explicit in expecting students to augment or forge their identity within the English discipline.

*<u>Other Themes in the CCSS</u>*

In comparison to DP English LL, the CCSS English Language Arts standards place much greater emphasis on technical accuracy and conventions of standard English. Whereas students are only required to communicate in a 'clear, logical and persuasive way' in DP English LL, the CCSS anchor standards stipulate that students must demonstrate 'command' of 'standard English grammar', including 'capitalisation, punctuation and spelling when writing'. DP English LL is ambiguous as to the extent that 'clear' communication requires a command of technical accuracy.

The CCSS English Language Arts standards in Writing underline the importance of 'Research to Build and Present Knowledge' in English, requiring students to demonstrate competence in conducting multiple, time-variable research projects. In contrast, DP English LL aims and assessment objectives make no explicit reference to independent study requiring the gathering of information to inform assessed work. Extensive reference in the DP subject specification is made to the mandatory ‘learner portfolio’, which requires students to collate work and reflect upon literary texts. The learner portfolio does not appear within the aims and assessment objectives, however, so there is this difference at the level of stated learning outcomes; the learner portfolio is also not formally assessed.

In summary, the CCSS require students to explicitly show technical competence and understanding of standard English in communication whereas the DP’s requirements in this area are broader. The CCSS also place more explicit emphasis at this level upon students conducting independent research and carrying out projects.

### 5.1.2 Content – English

This section compares and contrasts the content of English LL and the CCSS standards falling within the category of English. In order to support visual comparison at-a-glance, the DP and CCSS content is presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 7: DP English A: language and literature content visualiser*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Areas of exploration | **Readers, Writers and Texts** | Why and how do we study language and literature? | How are we affected by texts in various ways? | In what ways is meaning constructed, negotiated, expressed and interpreted? | How does language use vary amongst text types and amongst literary forms? | How does the structure or style of a text affect meaning? | How do texts offer insights and challenges? |
| | **Time and Space** | How important is the cultural or historical context to the production and reception of a text? | How do we approach texts from different times and cultures to our own? | To what extent do texts offer insight into another culture? | How does the meaning and impact of a text change over time? | How do texts reflect, represent or form a part of cultural practices? | How does language represent social distinctions and identities? |
| | **Intertextuality: Connecting Texts** | How do texts adhere to and deviate from conventions associated with literary forms or text types? | How do conventions and systems of reference evolve over time? | In what ways can diverse texts share points of similarity? | How valid is the notion of a classic text? | How can texts offer multiple perspectives of a single issue, topic or theme? | In what ways can comparison and interpretation be transformative? |
| **Literary works** | Four texts should take into account the following considerations: | Authors | Literary forms | Period | Place | | |

*Figure 8: CCSS English content visualiser*

| | | | | |
|---|---|---|---|---|
| **Reading: Literature (grade 11-12)** | Key ideas and details | Craft and structure | Integration of knowledge and ideas | Range of reading and level of text complexity |
| **Reading Informational Text (grade 11-12)** | Key ideas and details | Craft and structure | Integration of knowledge and ideas | Range of reading and level of text complexity |
| **Writing (grade 11-12)** | Text types and Purposes | Production and Distribution of Writing | Research to Build and Present Knowledge | Range of Writing |
| **Speaking and Listening (grade 11-12)** | Comprehension and Collaboration | Presentation of Knowledge and Ideas | | |
| **Language (grade 11-12)** | Conventions of Standard English | Knowledge of Language | Vocabulary Acquisition and Use | |

*Structure*

Subject content in DP English LL is primarily guided by three overlapping, conceptual areas of exploration: the nature of interactions between readers, writers and texts; the way texts interact with time and space; and intertextuality, meaning how texts interact with one another. These areas of exploration are then narrowed down to constituent guiding questions. For example, in the 'readers, writers and texts' area of exploration, it is suggested that students understand 'Why and how […] we study language and literature.'

In comparison, the CCSS identify four key strands in English – Reading, Writing, Speaking and Listening, and Language – and break these down into no more than ten anchor standards defining taught content at a more granular level than DP English LL. The structure of these anchor standards is the same irrespective of the age group taught; the substance of each is tailored to account for greater challenge as students age.

Differing principles guide the choice of literary texts for each programme. DP English LL requires teachers to select either four or six literary texts (four in the SL and six in the HL) from a range of criteria including author, literary form, period, and place. The CCSS expect teachers to evaluate texts in three different ways: quantitatively, qualitatively, and the suitability of the text to the reader dependant on task.

The range of non-literary forms students can access within each programme also differs. In DP English LL, students must study extended, full-length major non-literary texts or groups of shorter, non-literary texts; these must be balanced equally against literary texts, and may include forms such as infographics, screenplays, and works of art. The CCSS require students to study historical, scientific, and technical texts. In only specifying conventional non-literary forms such as 'speeches' and 'memoirs', the CCSS range is explicitly a little more limited than the choice in DP English LL.

To summarise, the structure of DP English LL is broad and led by areas of exploration and smaller guiding questions, whereas the structure of CCSS English breaks down content into discrete standards, and tailors them to age groups. The literary text reading requirements for DP English LL are drawn from more strict criteria than the CCSS, where text choice is guided by principles. Conversely, students following the CCSS must select non-literary texts from a narrower pool than in the DP English LL.

*Content Alignment*

To complement the analysis, the figure below represents a simplified summary of the CCSS content alignment, at topic-level, with DP English LL.

The conceptual nature of the DP English LL subject content encourages students to think metacognitively about the discipline to an extent that is absent from what is explicitly articulated in the CCSS for English. The CCSS never require students to explicitly explore the validity of the western canon, as expressed in the DP guiding question 'How valid is the notion of a classic text?'. Likewise, the granular level of detail in the standards does not rise to the conceptual level of a question like the DP's 'How do texts offer insights and challenges?'.

The CCSS and DP English LL both address the rationale behind the study of English to different extents. Students in studying DP English LL explore the guiding question, 'Why and how do we study language and literature?'. Doing so fosters within students an appreciation of language and literature's relevance to other academic disciplines as well as their own role and responsibility as a student of the subject. In the CCSS, students learn 'how' to study English through developing skills of textual criticism and so on, yet these skills are not framed in a way which explicitly allows students to appreciate the importance of their study of language and literature in the way that DP English LL does.

*Figure 9: Summary of content alignment between the DP English LL topics and CCSS content*

| English A: language and literature | Presence in CCSS |
|---|---|
| **Areas of exploration – readers, writers and texts** | |
| Why and how do we study language and literature? | |
| How are we affected by texts in various ways? | |
| In what ways is meaning constructed, negotiated, expressed and interpreted? | |
| How does language use vary amongst text types and amongst literary forms? | |
| How does the structure or style of a text affect meaning? | |
| How do texts offer insights and challenges? | |
| **Areas of exploration – time and space** | |
| How important is the cultural or historical context to the production and reception of a text? | |
| How do we approach texts from different times and cultures to our own? | |
| To what extent do texts offer insight into another culture? | |
| How does the meaning and impact of a text change over time? | |
| How do texts reflect, represent or form a part of cultural practices? | |
| How does language represent social distinctions and identities? | |
| **Areas of exploration – intertextuality: connecting texts** | |
| How do texts adhere to and deviate from conventions associated with literary forms or text types? | |
| How do conventions and systems of reference evolve over time? | |
| In what ways can diverse texts share points of similarity? | |
| How valid is the notion of a classic text? | |
| How can texts offer multiple perspectives of a single issue, topic or theme? | |
| In what ways can comparison and interpretation be transformative? | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *There is strong presence of this topic in the CCSS* | | *There is partial presence of this topic in the CCSS* | | *There is little or no presence of this topic in the CCSS* |

In some cases, DP English LL and the CCSS for English align in both subject breadth and depth. This is especially the case when students compare two different texts and explore points of similarity, and in understanding how a writer creates meaning using technical methods and word choices.

The principles determining text choices in each programme influence the breadth and depth of the subject content in each course. Whereas the CCSS, arguably, allow teachers to pick any text they wish to teach to students so long as it aligns to the reader in terms of readability, level of demand, and other variables, DP English LL is more prescriptive. For example, DP teachers must, at HL, select works by authors from at least two different continents.

Altogether, the DP permits greater depth in content, particularly through the way it encourages students to think metacognitively about the subject. In some areas, the CCSS enable the development of skills which may allow greater depth of thought, but that greater depth of conceptual complexity is not explicitly articulated in the standards. Regarding text choice, the DP is more prescriptive in what reading is allowed, whereas the CCSS potentially cover a larger range of texts – though practical levels of variation across different US schools are not fully revealed by the standards.

*Table 12: CCSS English content which is not covered by DP English LL*

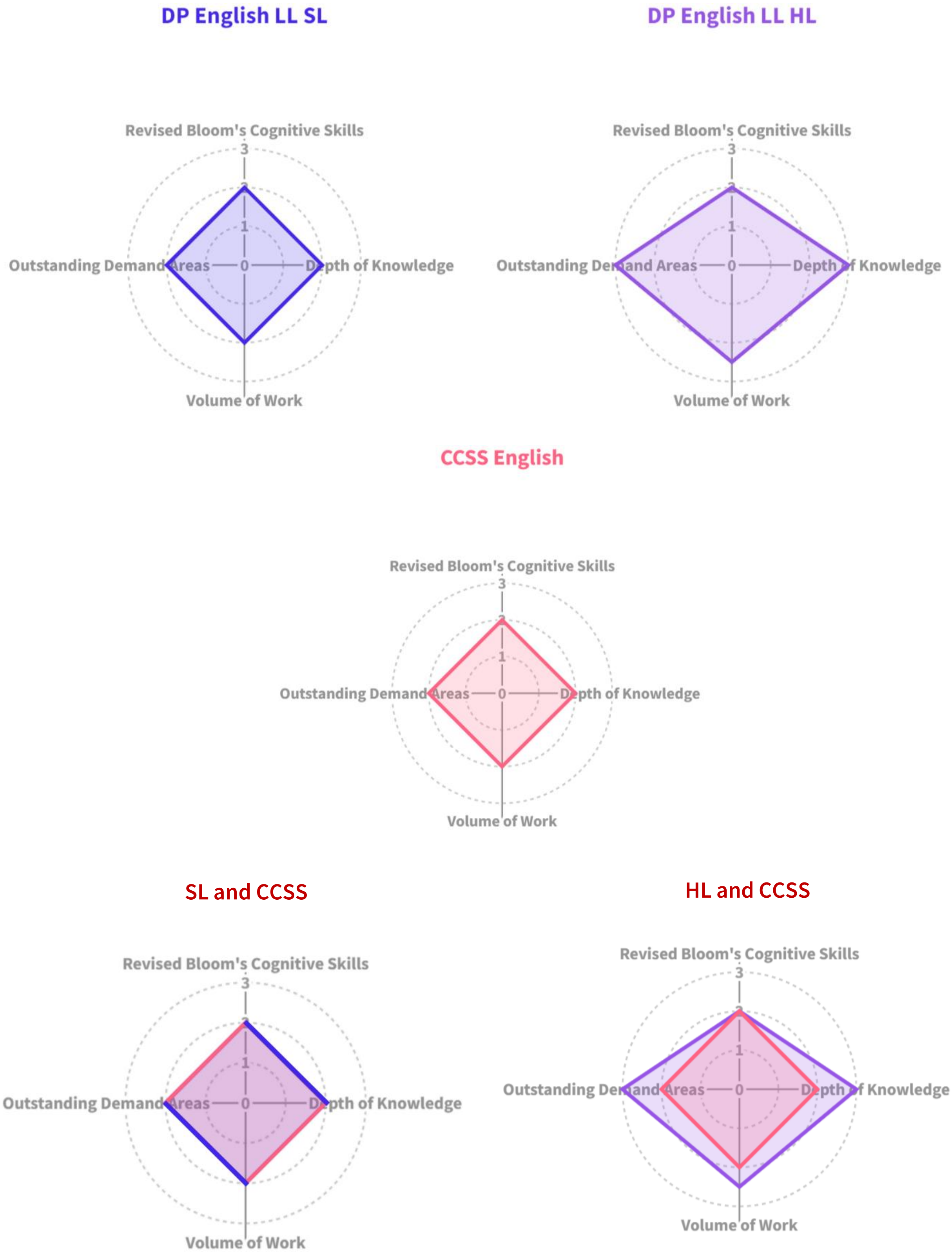
| **Significant CCSS content which is not included in DP English LL** |
|---|
| Overall, almost all content within the CCSS is present in DP English LL, beyond a few mandatorily selected topics:<br><br>○ Some canonical texts, such as the reading of one text by Shakespeare, one play by an American dramatist, and a range of 18-20th century foundational works of American literature, are mandatorily studied in CCSS grades 11-12. The DP English LL does not require students to cover these specific topics.<br><br>○ While some content in the CCSS may not be explicitly covered by the DP English LL documentation, all significant content is highly likely to be implicitly studied. For example, students in the CCSS must 'Analyze nuances in the meaning of words with similar denotations.' Although the technical term, 'denotations' does not appear within the DP English LL course, a teacher would still likely explain what it means to students should a classroom situation demand it (for example, in exploring how texts are analysed). |

* Significant content does not include topics which are typically studied *prior* to upper secondary

### 5.1.3 Demand – English

The DP English LL and CCSS English curricula were analysed using the same demand tool in order to create a demand profile for DP English LL SL, DP English LL HL, and CCSS English. These demand profiles are presented below in the form of radar diagrams, with the last two diagrams showing the CCSS superimposed onto SL and HL respectively, enabling immediate visual comparison.

*Figure 10: Visual representations of subject demand*




The panel of experts carried out a detailed analysis of each course and reached a consensus on the scores shown in the profiles above. The following points were particularly important within the panel discussion:

- Regarding the scores for **Bloom's Cognitive Skills:**
  - DP English LL has the same learning outcomes for both SL and HL, meaning that these scores are the same. Both DP and CCSS were judged to show a few elements of sophisticated metacognition, indicating *some* presence of evaluation and synthesis. However, these elements were often found to be implicit (rather than explicit) in both cases, with the majority of learning outcomes focusing explicitly on analysis, application, knowledge and understanding. A score of 2 was provided to all.

- Regarding the scores for **Depth of Knowledge:**
  - The DP English LL SL was judged to merit a score of 2, as it was found to provide many opportunities for strategic thinking, and the subject content encourages conceptual thinking of English as a subject but was not found to expect learners to significantly engage in extended thinking. Similarly, the CCSS English, also awarded a 2, was found to provide sufficient opportunities for learners to think strategically about the subject, and engage with complex levels of knowledge, as learners are expected to introduce 'precise, knowledgeable claims, establish [their] significance, distinguish [them] from alternate and opposing claims,' and organise them logically.[69]
  - For the DP English LL HL, the long-term reflective nature of the HL essay, based on the exploration carried out throughout the course in the learner portfolio, was found to feature a significant component of extended thinking, pushing the score to a 3.

- Regarding the scores for **Volume of Work:**
  - DP English LL SL was judged to comprise a moderate-heavy workload, warranting a score of 2, as students are expected to engage with a high number of themes and spend a significant proportion of their time on issues beyond basic conceptual depth, including complex multidisciplinary concepts. CCSS English was also judged to comprise a moderate-heavy workload, though the rationale for this differed – it was the very high number of themes covered that rendered it a score of 2, rather than the cognitive complexity of the content, which was found to be lower.
  - For the DP English LL HL, the panel agreed on a volume of work demand score of 2.5 due to the higher number of texts studied (compared to the SL) and the addition of the HL essay. The proportion of time spent on complex reasoning was judged to push the volume of work score into a 2.5.

- Regarding the scores for **Outstanding Areas of Subject Demand:**
  - A score of 2 (3-4 stretch areas) was awarded to the DP English LL SL due to the significant presence of challenging guiding questions in the subject guide – providing frequent opportunities for higher order thinking – the expansive and exploratory nature of the syllabus and the fact that students are asked to explore different schools of thought and interrogate the development of texts over time.

[69] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. English Language Arts Standards*. http://www.corestandards.org/ELA-Literacy/W/11-12/1/a/

- For the DP English LL HL, it was found that the HL essay and the requirement to explore an additional translated text pushed it to a score of 3.
- For the CCSS, a score of 2 was awarded, with stretch areas being identified in the requirements to evaluate different formal interpretations of texts (Reading) and to draw evidence from complex texts (matching US Supreme Court Case majority opinions in complexity) (Writing). Moreover, stretch was also found in the framing of collaborative tasks in the language of public life and citizenship (Speaking and Listening), explicitly increasing the formal, procedural and linguistic expectations on learners to that beyond high school.

## 5.2 Mathematics

The following is the list of subjects used in the mathematics subject comparison analysis.

**Mathematics: analysis and approaches**[70]
Mathematics: analysis and approaches (AA) is a subject option from the mathematics group in the DP curriculum – offered at both standard level (SL) and higher level (HL). This subject is intended for students who are interested in both real and abstract applications of mathematical concepts and enjoy problem solving and generalisation. SL is suitable for students who want to study a good level of mathematics, but not at an advanced level. Therefore, SL prepares students for further study in areas involving mathematical elements, such as geography. HL is suitable for students who want an in-depth study of mathematics and enjoy solving challenging problems. Therefore, HL prepares students for further study in mathematics, as well as other areas with a strong mathematical focus, such as physics and engineering.

**Mathematics: applications and interpretation**[71]
Mathematics: applications and interpretation (AI) is a subject option from the mathematics group in the DP curriculum – offered at both SL and HL. This subject is intended for students who are interested in exploring more practical applications of mathematics and would enjoy using mathematical models and technology. SL is most suitable for those who want to obtain a good level of knowledge of mathematics, with a focus on real-world applications. Therefore, SL prepares students for further study in areas with some practical mathematics elements, such as biology and business. HL is suitable for students wishing to gain more in-depth knowledge of mathematics, with a focus on real-world situations and the applications of mathematics.

**Common Core State Standards for Mathematics**[72]
The Common Core State Standards for Mathematics (CCSSM) include standards for mathematical practice and standards for mathematical content. These standards describe what students should be able to understand and do in their mathematics study, however they do not comprehensively detail all content which is learnt, especially for advanced courses taken later in high school – 'fourth courses'[73]. This analysis focuses on high school standards (grades 9-12).

### 5.2.1 Learning Outcomes – Mathematics

For its mathematics learning outcomes, the DP sets out aims and assessment objectives for all subjects within the mathematics subject group – hence the extracted themes are the same for mathematics: analysis and approaches and mathematics: applications and interpretation.

---

[70] International Baccalaureate. (2019). *Mathematics: analysis and approaches guide.*
[71] International Baccalaureate. (2019). *Mathematics: applications and interpretation guide.*
[72] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics.* Mathematics Standards | Common Core State Standards Initiative (corestandards.org)
[73] National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core Standards for Mathematics. Appendix A: Designing High School Mathematics Courses Based on the Common Core State Standards.* p. 8. Mathematics Appendix A_Teal1.indd (corestandards.org)

Similarly, CCSSM set out the Standards for Mathematical Practice, which are the same from kindergarten to grade 12. The mathematical practices comprise of seven standards, with detailed descriptions for each. The table below shows the comparison of these with the DP's learning outcome themes.

*Table 13: Presence of the DP mathematics subject group learning outcome themes in the CCSSM*

| **Themes extracted from the learning outcomes in the DP mathematics subject group** | **Presence in the CCSSM's learning outcomes** | |
|---|---|---|
| 1. Being aware of, and engaging with, mathematics in its wider context | | Not present. |
| 2. Developing learning skills; having a positive and resilient attitude, working both independently and collaboratively, being reflective and evaluating work | | Present in CCSS are students' learning skills, including critical reflection on work, perseverance in problem solving, and building a positive attitude to mathematics. |
| 3. Using inquiry-based approaches | | Not present. |
| 4. Understanding the concepts, principles and nature of mathematics and applying concepts and procedures to a range of contexts | | Present in CCSS, as they promote conceptual understanding and the development of skills. |
| 5. Making links and generalisations | | Present in the CCSS. The reasoning standard demonstrates the theme by incorporating abstraction skills, such as the ability to 'de-contextualise'. Furthermore, standards 7 and 8 expect students to 'look for and make use of structure' and 'regularity in repeated reasoning' |
| 6. Developing critical/creative thinking skills e.g. problem-solving and reasoning | | Present in the CCSS, as critical thinking skills such as problem-solving and reasoning were two of the seven standards and present in others. |
| 7. Communicating mathematics clearly and in various forms | | Partially present in the CCSS as, for example, 'attending to precision' is one of the seven standards. |
| 8. Knowing how technology and mathematics influence each other and using technology to develop ideas and solve problems | | Present in the CCSS, as students are expected to use a range of technology to solve problems and deepen understanding. |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *This theme is well-evidenced in the learning outcomes of the CCSS.* | | *This theme is partially evidenced in the learning outcomes of the CCSS.* | | *This theme is not evident in the learning outcomes of the CCSS.* |

*Presence of the DP's Learning Outcome Themes:*
There is strong alignment with some of the DP's learning outcome themes in the mathematical practices, with the CCSS also promoting conceptual understanding and the development of higher-order skills. Like the DP, critical thinking skills such as problem-solving and reasoning are both key outcomes as they make up two of the seven standards and are also highly present in others. Also embedded into the standards are other critical processes such as analysis and evaluation.

The DP's theme of making links and generalisations is present in several practices. The 'reasoning' standard demonstrates the theme by incorporating abstraction skills, such as the ability to 'de-contextualise', and two other standards demonstrate the theme by describing students' ability to look for 'patterns' and 'regularity in repeated reasoning' (with the aim to be able to abstract and/or make generalisations).

As in the DP, the standards in the mathematical practices also expect students to be able to use a range of technology and to be able to communicate mathematical ideas concisely and accurately. Furthermore, the standards outline the development of similar learning skills to the DP, such as being able to critically reflect on work, persevere in problem solving, and build a positive attitude to mathematics.

Despite the many similarities between the learning outcome themes of the DP and the CCSSM, some themes had less alignment. The least present theme is that of engaging with maths in its wider context, as real-world relevance is only considered with respect to modelling. Unlike the DP, the CCSSM do not include global and historical perspectives, links to other disciplines, or questioning of the social, moral, and ethical implications of mathematics. Also notably, though the CCSSM practices have elements of inquiry-based approaches, taking this approach in general is not a focus, and working within the context of an investigation is not a feature in the standards. Furthermore, the standards do not explicitly describe the development of collaboration skills or the ability to work independently.

*Other Themes in the CCSSM*
The mathematical practices do not contain any significant theme or learning outcome that is not present in the DP. However, a difference of note is that the CCSSM expectations include more specific outcomes of how students will employ and refine their powers of generalisation and abstraction, which they state will be through 'looking for and expressing regularity in repeated reasoning'. They also state that students should be able to 'look closely and discern a pattern or structure'. Hence, the CCSSM are more specific in their outcomes about the types of deeper learning they want their students to be engaging with and exploring in their mathematical studies. However, though these are not explicitly described in DP's learning outcomes, similar ideas (and others) are reflected in the 'conceptual understandings' and 'connections' sections of the DP content descriptions.

Another outcome which is given more attention in the CCSSM is that of modelling, which is one of the seven standards in the mathematical practices. This standard describes students being able to solve problems, analyse relationships, use assumptions and approximations in complex situations, interpret results, and improve models. Although modelling is a not a focus in the learning outcomes of the DP, it is present in the curriculum documents which describe modelling processes.

### 5.2.2 Content – Mathematics

This section compares and contrasts the content of the DP mathematics subjects and the CCSSM. In order to support visual comparison at-a-glance, the mathematics content for the DP and CCSSM are presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 11: DP mathematics: analysis and approaches content visualiser*

| | Standard level topics | Additional higher level topics |
|---|---|---|
| **Topic 1 Number and algebra** | 1.1 Standard form; 1.2 Arithmetic sequences and Series; 1.3 Geometric sequences and series; 1.4 Financial applications; 1.5 Integer exponents and Intro to logarithms 1.6 Simple proof; 1.7 Rational exponents and laws of logarithms; 1.8 Sum of infinite convergent geometric sequences; 1.9 Binomial theorem (natural number) | 1.10 Counting principles and extended binomial theorem; 1.11 Partial fractions; 1.12 Complex numbers intro; 1.13 Polar and Euler form; 1.14 Complex roots, De Moivre's theorem and powers/roots of complex numbers; 1.15 Proof by counter example, contradiction, and induction; 1.16 Solutions of systems of linear equations |
| **Topic 2 Functions** | 2.1 Gradients and equations of straight lines; 2.2 Intro to functions; 2.3 Graphing functions; 2.4 Key features of graphs; 2.5 Composite, identity, and inverse functions; 2.6 Quadratic functions; 2.7 Solving quadratic equations and inequalities & the discriminant; 2.8 Reciprocal and rational functions; 2.9 Exponential and logarithmic functions; 2.10 Graphical and analytical solutions; 2.11 Transformations | 2.12 Polynomial functions; 2.13 Harder rational functions; 2.14 Odd, even, and inverse functions; 2.15 Graphical and analytical solutions of inequalities; 2.16 Further graphs, including modulus and solutions |
| **Topic 3 Geometry and trigonometry** | 3.1 Geometry recap; 3.2 Trigonometry recap; 3.3 Applications and diagrams; 3.4 Circles and radians; 3.5 Definitions, exact values, and sine rule for ambiguous case; 3.6 Identities and relationships; 3.7 Functions and transformations of sin, cos, and tan; 3.8 Solving trigonometric equations graphically and analytically | 3.9 Reciprocal trigonometric ratios, identities, and inverse functions; 3.10 Compound angle identities and double angle for tan; 3.11 Symmetry properties; 3.12 Intro to vectors; 3.13 Scalar product and application; 3.14 Vector equation of a line and application; 3.15 Coincident, parallel, skew, and intersecting lines; 3.16 Cross product of vectors; 3.17 Planes; 3.18 Intersections and angles (planes) |
| **Topic 4 Statistics and probability** | 4.1 Sampling; 4.2 Presenting data (tables, histograms, cumulative freq.); 4.3 Measures of central tendency and dispersion; 4.4 Correlation and regression line; 4.5 Intro to probability; 4.6 Diagrams, conditional probability, combined or independent events; 4.7 Discrete random variables; 4.8 Binomial distribution; 4.9 Normal distribution; 4.10 Equation of regression line of x on y; 4.11 Formulae for conditional probabilities and independent events; 4.12 Standardisation of normal variables (z-values) | 4.13 Bayes' theorem; 4.14 Continuous random variables |
| **Topic 5 Calculus** | 5.1 Intro to limits and derivatives; 5.2 Increasing and decreasing functions; 5.3 Derivative of $f(x)=ax^n$; 5.4 Tangents and normal; 5.5 Definite integrals; 5.6 More derivatives and use of product, chain, and quotient rules; 5.7 The second derivative; 5.8 Maximum, minimum and inflection points, and optimization; 5.9 Kinematic problems; 5.10 Indefinite integrals and integration by inspection and substitution; 5.11 Definite integrals and area of a curve | 5.12 Continuity, differentiability, limits, and higher derivatives; 5.13 Evaluation of limits and L'Hopitals rule; 5.14 Implicit differentiation; 5.15 Further derivatives and indefinite integrals; 5.16 Integration by substitution and by parts; 5.17 Volumes of revolution; 5.18 First order differential equations; 5.19 Maclaurin series |
| **The Toolkit and mathematical exploration** | The exploration is a piece of written work that involves investigating an area of mathematics. | |

*Figure 12: DP mathematics: applications and interpretation content visualiser*

| | Standard level topics | Additional higher level topics |
|---|---|---|
| **Topic 1 Number and algebra** | 1.1 Standard form; 1.2 Arithmetic sequences and series; 1.3 Geometric sequences and series; 1.4 Financial applications of geometric sequences and series; 1.5 Integer exponents and intro to logarithms; 1.6 Approximation, estimation, bounds and errors; 1.7 Amortization and annuities using technology; 1.8 Using technology to solve systems of equations and polynomials | 1.9 Laws of logarithms; 1.10 Rational exponents; 1.11 The sum of infinite geometric sequences; 1.12 Complex Numbers; 1.13 Euler and Polar form; 1.14 Matrices; 1.15 Eigenvalues and eigenvectors |
| **Topic 2 Functions** | 2.1 Gradients and equations of straight lines; 2.2 Intro to functions; 2.3 Graphing functions; 2.4 Key features of graphs; 2.5 Modelling with functions; 2.6 Modelling skills | 2.7 Composite and inverse functions; 2.8 Transformations; 2.9 Modelling further functions; 2.10 Using logarithms to scale numbers and linearize data |
| **Topic 3 Geometry and trigonometry** | 3.1 Geometry recap; 3.2 Trigonometry recap; 3.3 Applications and diagrams; 3.4 Circles, sectors, and arcs; 3.5 Equations of perpendicular bisectors; 3.6 Voronoi diagrams | 3.7 Radians; 3.8 Sin, Cos, Tan definitions, and Pythagorean Identity; 3.9 Matrix transformations; 3.10 Vectors introduction and notation; 3.11 Vector equation of a line; 3.12 Vector application to kinematics; 3.13 Scalar and cross product; 3.14 Graph theory and simple, directed and subgraphs; 3.15 Adjacency matrices and weighted adjacency tables; 3.16 Decision math |
| **Topic 4 Statistics and probability** | 4.1 Sampling; 4.2 Presenting data (tables, histograms, cumulative freq.); 4.3 Measures of central tendency and dispersion; 4.4 Correlation and regression line; 4.5 Intro to probability; 4.6 Diagrams, conditional probability, combined or independent events; 4.7 Discrete random variables; 4.8 Binomial distribution; 4.9 Normal distribution; 4.10 Spearman's rank; 4.11 Hypothesis testing, chi-squared and t-tests | 4.12 Collecting and organising data and testing for reliability and validity; 4.13 regression, residuals, coefficient of determination; 4.14 Linear transformations, linear combinations, unbiased estimations; 4.15 Central Limit theorem; 4.16 Confidence intervals; 4.17 Poisson distribution; 4.18 Further hypothesis testing; 4.19 Transition matrices and Markov chains |
| **Topic 5 Calculus** | 5.1 Intro to limits and derivatives; 5.2 Increasing and decreasing functions; 5.3 Derivative of $f(x)=ax^n$; 5.4 Tangents and normal; 5.5 Definite integrals; 5.6 Maximum and minimum points; 5.7 Optimisation; 5.8 Area using trapezoidal rule | 5.9 More derivatives and the chain, product, and quotient rule; 5.10 Second derivatives; 5.11 Finding further integrals and integration by inspection and substitution; 5.12 Area of a region and volumes of revolution; 5.13 Kinematic problems; 5.14 Differential equations; 5.15 Slope fields and their diagrams; 5.16 Euler's method and numerical solutions to differential equations and coupled systems; 5.17 Phase portraits; 5.18 Simple second order differential equations |
| **The Toolkit and mathematical exploration** | The exploration is a piece of written work that involves investigating an area of mathematics. | |

*Figure 13: CCSS for mathematics content visualiser*

| | | | | | | |
|---|---|---|---|---|---|---|
| **Number and quantity** | The real number system | Quantities | The complex number system | Vector & matrix quantities | | |
| **Algebra** | Seeing structure in expressions | Arithmetic with polynomials and rational functions | Creating equations | Reasoning with equations and inequalities | | |
| **Functions** | Interpreting functions | Building functions | Linear, quadratic, and exponential models | Trigonometric functions | | |
| **Modelling** | *'Modelling is best interpreted not as a collection of isolated topics but rather in relation to other standards'* | | | | | |
| **Geometry** | Congruence | Similarity, right triangles, and trigonometry | Circles | Expressing geometric properties with equations | Geometric measurement and dimension | Modelling with geometry |
| **Statistics and probability** | Interpreting categorical and quantitative data | Making inferences and justifying conclusions | Conditional probability and the rules of probability | Using probability to make decisions | | |

*Structure*

The CCSSM are learning goals that are expected to be achieved by students completing grades 9-12. Unlike how the DP sets out all the content for the whole mathematics subject group, the standards are not intended to be seen as the curriculum for all mathematics study. For high school, the CCSSM are structured into ‘Conceptual Categories’, namely ‘Number and quantities’, ‘Algebra’, ‘Functions’, ‘Geometry’, ‘Modelling’, and ‘Statistics and probability’. ‘Modelling’ is not intended as an isolated topic, but as an area to be developed in relation to other standards. Taking this away, the number of main topics is the same as the DP, which has ‘Number and algebra’, ‘Functions’, ‘Geometry and trigonometry’, ‘Statistics and probability’, and ‘Calculus’. As can be seen, there are clear similarities in the types of main topics covered.

For the CCSSM, trigonometry is found within ‘Functions’ and ‘Geometry’, rather than as a separately named topic area. Like the DP, each main area in the CCSSM is broken down into smaller areas, with these being the ’domains’, within which are the standards. Similarly, in this breakdown, both have content that is marked as higher level and is intended for more difficult courses, in the DP this is the additional higher level (AHL) content and for the CCSSM this is content studied in a ‘fourth course’. In the US, schools often teach Algebra I, Geometry, and Algebra II to all students, followed by a choice of fourth courses ranging in difficulty, such as Pre-calculus, Calculus, and Advanced Statistics. However, where the DP details all the higher level content required to be taught, the CCSSM only point to a few new areas or further extensions, which are not themselves reflective of all content that can be studied in a fourth course. Many students take fourth courses, with choices depending on what students will do after high school.

Another main difference in the structure of mathematical content between the DP and the CCSSM is the number of years with which they relate to, for the DP this is two years, where for the US it can be 3-4 years, with also options for fast tracking and starting content earlier in grades 7 or 8. Finally, the CCSSM do not separate content with regards to focus, such as pure and applied, as the DP does to an extent with AA and AI.

*Content Alignment*

To complement the analysis, the figures below represent a simplified summary of the CCSSM content alignment, at topic-level, with mathematics: analysis and approaches (SL and HL) and mathematics: applications and interpretation (SL and HL).

*Figure 14: Summary of the content alignment between the topics in AA and the CCSSM content.*

| Mathematics: analysis and approaches topics | Presence of SL content in the CCSSM | Presence of AHL content in the CCSSM |
|---|---|---|
| 1. Number and algebra | | |
| 2. Functions | | |
| 3. Geometry and trigonometry | | |
| 4. Statistics and probability | | |
| 5. Calculus | | |

*Figure 15: Summary of the content alignment between the topics in AI and the CCSSM content.*

| Mathematics: applications and interpretation topics | Presence of SL content in the CCSSM | Presence of AHL content in the CCSSM |
|---|---|---|
| 1. Number and algebra | | |
| 2. Functions | | |
| 3. Geometry and trigonometry | | |
| 4. Statistics and probability | | |
| 5. Calculus | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *There is strong presence of this topic in the CCSS* | | *There is partial presence of this topic in the CCSS* | | *There is little or no presence of this topics in the CCSS* |

<u>*Mathematics: analysis and approaches*</u>

Mathematics: analysis and approaches (AA) content is present in the CCSSM for all topics, except ‘Calculus’. Calculus is usually taken in grade 12 by those who are mathematically able and may intend to pursue a STEM-related course in higher education. The mapping of content shows that CCSSM have the most alignments with the AA topics of ‘Number and algebra’ and ‘Functions’. The standards which relate to studied content in the first three courses of mathematics study involve nearly all of the key areas in both of these main topics, including sequences, rational exponents, binomial theorem, complex numbers, and several functions and graphs. In these topics, most significant SL content is covered by the CCSSM, along with some partial AHL alignments. If the CCSSM relating to fourth courses are also considered, then alignment with AHL is further strengthened due to more functions being explored and the inclusion of more difficult concepts in complex numbers. Although proof is a feature in the CCSSM, it can be noted that methods of proof by induction, comparison, or counterexample were not required.

Some SL content from ‘Geometry and trigonometry’ is present in the CCSSM, with fourth course standards also including the study of trigonometric functions and equations. With regards to AHL content, the CCSSM indicate that an introduction to vectors would be studied in a fourth course, with further depth of study likely to depend on the course. In contrast to AA, the CCSSM focus on areas such as similarity, congruence, constructions, circle theorems, and conic sections.

For ‘Statistics and probability’, the CCSSM have strong alignment with the sub-topics of presenting data, measures of central tendency and spread, correlation and linear regression, and probability formulae, with random variables being an area of focus in fourth course study. The CCSSM also include the development of concepts involving populations and sampling, which are not in the scope of AA.

Further, in contrast to AA, the standards place a greater emphasis on modelling and also indicate that matrices will be covered in a fourth course. Overall, the CCSSM strongly align with AA SL content in ‘Number and algebra’ and ‘Functions’, and also align well with ‘Geometry and trigonometry’ and ‘Statistics and probability’. Of these topics, for AHL content, the CCSSM have some alignment with ‘Number and algebra’ and ‘Functions’, limited alignment with ‘Geometry and trigonometry’, and none with ‘Statistics and probability’. Lastly, the CCSSM do not include standards related to calculus, thus there is no alignment with the topic of 'Calculus' for both SL and AHL content. Therefore, the content depth in AA HL exceeds that of the CCSSM in this area.

*Mathematics: applications and interpretation*

Mathematics: applications and interpretation (AI) content is present in the CCSSM for all topics, except 'Calculus'. The mapping of content shows that the CCSSM strongly align with SL content in the topics of 'Functions' and 'Geometry and trigonometry' – Voronoi diagrams excluded. Strong alignment with 'Functions' comes from the CCSSM focus on modelling, which is intended to be integrated into many areas of study. Several AHL sub-topics are also present in both topics, most notably vectors are introduced in fourth course study, though graph theory and decision mathematics are not present in any of the CCSSM. Instead of content similar to AI 'Geometry and trigonometry', the CCSSM focus on areas such as similarity, congruence, constructions, circle theorems, and conic sections.

There is a mixture of SL and AHL 'Number and algebra' content present in the CCSSM, which have fourth course standards involving complex numbers and matrices. However, the significant areas of amortization and annuities, eigenvalues and eigenvectors, and laws of logarithms are not included in the CCSSM. In contrast to AI, the CCSSM require the use of proof (for polynomial identities, trigonometric identities, and geometric theorems) and include other AA topics such as the binomial theorem.

For 'Statistics and probability', the CCSSM have strong alignments with the sub-topics of presenting data, measures of central tendency and spread, correlation and linear regression, probability, and the normal distribution – with also some similar ideas involving sampling and populations. However, approximately half of the topic content is not present, including non-linear regression, Binomial and Poisson distributions, transition matrices, and much of hypothesis testing. Overall, the CCSSM have good alignment with both SL and AHL content for 'Functions' and 'Geometry and trigonometry' – though graph theory and decision mathematics are not covered. Also, the CCSSM have a mixture of SL and AHL alignments with 'Number and algebra', less alignment with 'Statistics and probability', and no alignment at all with 'Calculus'. Therefore, AI HL exceeds the content depth of the CCSSM in these respects.

*Table 14: CCSSM content which is not covered by DP mathematics subjects*

| Significant CCSSM content not in AA (only) | Significant CCSSM content not in AI (only) |
|---|---|
| ○ Matrices<br>○ Modelling emphasis<br>○ Estimating population proportion and mean; developing a margin of error | ○ Proof<br>○ Rational and polynomial functions<br>○ Binomial theorem<br>○ Counting principles<br>○ Absolute value function |
| **Significant CCSSM content not in either DP mathematics subject *** | |

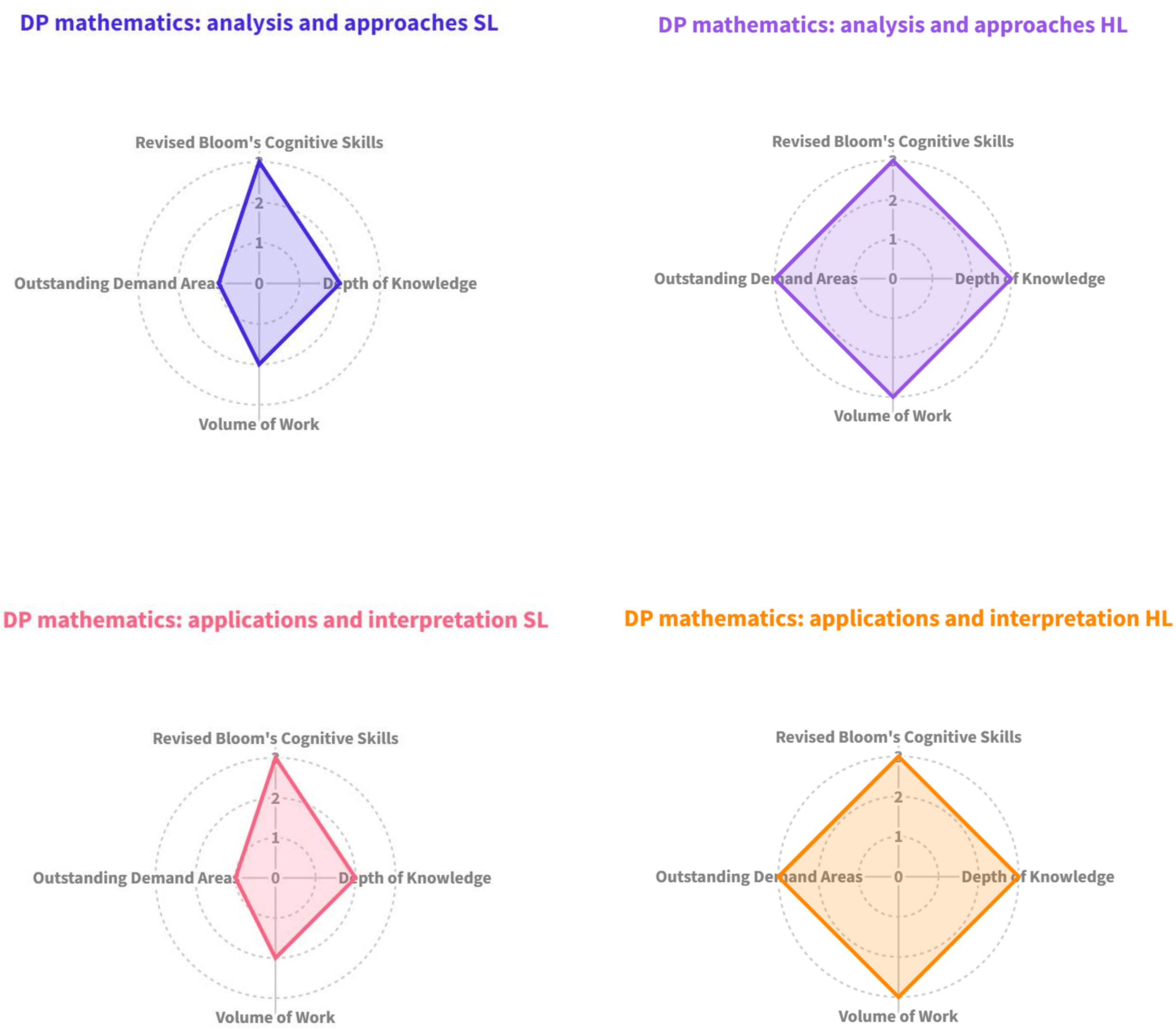
| |
|---|
| ○ Similarity<br>○ Congruence<br>○ Constructions<br>○ Circle Theorems<br>○ Conic Sections |

* Significant content does not include topics which are typically studied *prior* to upper secondary

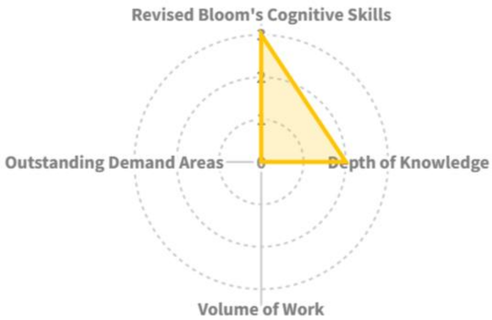
### 5.2.3 Demand – Mathematics

The DP mathematics curricula and CCSSM were analysed using the same demand tool in order to create a demand profile for DP mathematics: analysis and approaches (SL and HL), DP mathematics: applications and interpretation (SL and HL), and the CCSSM. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all the DP and CCSSM profiles superimposed in one place, enabling immediate visual comparison.

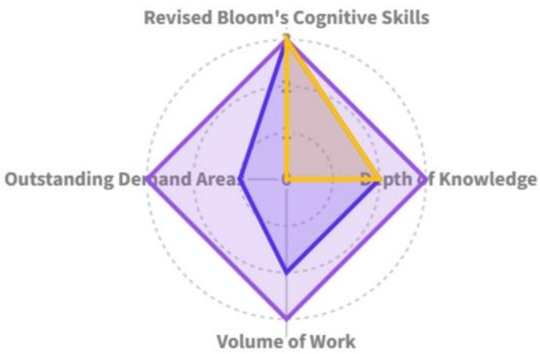
*Figure 16: Visual representations of subject demand*



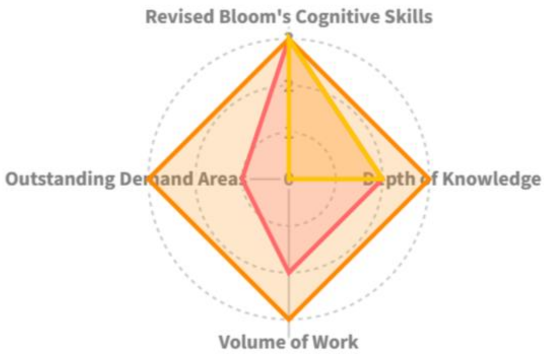
Common Core State Standards Mathematics




DP AA SL/HL and CCSSM




DP AI SL/HL and CCSSM




The panel of experts carried out a detailed analysis of each and reached a consensus on the scores shown in the profiles above. The following points were particularly important within the panel discussion:

- Regarding the scores for **Bloom's Cognitive Skills**:
    - The DP mathematics subject group learning outcomes apply to all subjects hence the scores are the same for mathematics: analysis and approaches (SL and HL) and mathematics: applications and interpretation (SL and HL). These outcomes were given a score of 3 on the basis that they strongly evidenced the development of critical and creative thinking skills through their focus on reasoning, inquiry-based approaches, reflection, generalisation, unfamiliar contexts, and consideration of wider implications.
    - The CCSSM similarly have one set of outcomes and received a score of 3 for their presence of higher order cognitive skills. The standards frequently used evaluation, creation, and analysis through references to critiquing, reflecting, analysing

relationships, searching for patterns, making generalisations, reasoning abstractly, improving models, and drawing conclusions.

- Regarding the scores for **Depth of Knowledge**:
  - Both DP mathematics subjects at SL were given a score of two. Both subjects were judged to cover the topics of ‘Number and algebra’, ‘Functions’, ‘Geometry and trigonometry’, ‘Statistics and probability’, and ‘Calculus’ in considerable detail, building in complexity and requiring a substantial amount of pre-requisite knowledge. At HL, both DP mathematics subjects were awarded a score of 3 for depth of knowledge. The subjects were judged to cover topics in a high level of detail, with many sub-topics having high complexity and requiring a large amount of pre-requisite knowledge.
  - The CCSSM were deemed to cover the topics of number, algebra, geometry, trigonometry, statistics, and probability in considerable detail, with evidence of complexity being built and pre-requisite knowledge being used in each. However, the CCSSM are less informative about ‘fourth courses’, which are available to be taken usually in the last two grades of high school, such as Pre-Calculus, Calculus, and AP Statistics. Hence the topics in the CCSSM alone did not include enough of the material typical of advanced mathematical study to be awarded a score of 3 for depth of knowledge.

- Regarding the scores for **Volume of Work:**
  - Both DP mathematics subjects at SL were deemed to comprise of a moderate-heavy volume of work and were given a score of 2. The panel concluded that the teaching time allotted to cover the different concepts is short (150 hours) but acknowledged that some sub-topics contained basic concepts and recapped prior learning, hence 2 was deemed an appropriate score. For HL, both DP mathematics subjects were considered to have a heavy volume of work, due to the short amount of time allocated (240 hours) and the level of complexity of the content, which (combined) merits a score of 3.
  - For the CCSSM, discussions acknowledged the difficulty of awarding a score in this category due to the lack of information about teaching hours and the likelihood of variation between states, therefore any score given should be considered as an approximation. Overall, a score of 0 for the volume of work was deemed appropriate for the CCSS, which was based on the standards covered in the first three years of high school, before fourth courses are taken. By the end of the three years, the content covered was deemed comparable to DP SL, though the inclusion of more basic content, due to high school beginning in grade 9, meant that the amount of content is not directly comparable. Regardless of this, the time allocation of three years was judged to be a generous amount of time to cover the standards and lack of contrary evidence meant that the score could not be raised above 0.

- Regarding the scores for **Outstanding Areas of Subject Demand:**
  - Both DP mathematics subjects at SL contain one area of outstanding demand, which is the ‘mathematical exploration’. This element of the SL subjects was considered to apply skills typically needed in higher education, such as extended

writing and presentation of mathematical concepts, student-led exploration, and academic writing skills. Therefore, a score of 1 was awarded to both SL subjects for the inclusion of this element. In addition to this, both subjects at HL have further areas of outstanding demand. For mathematics: analysis and approaches, some of the identified outstanding areas of demand are proof by induction, complex numbers (De Moivre's theorem), vectors (cross product, equations of planes and intersections), continuous random variables (probability density functions), and Maclaurin Series. For mathematics: applications and interpretation, some identified areas of outstanding demand were eigenvalues and eigenvectors, nonlinear regression, Markov chains, second order differential equations, slope fields, Euler's method, and phase portraits. Overall, there are a high number of outstanding areas of demand and a score of 3 was awarded to both HL subjects.

- In contrast, the CCSSM did not detail much of the content studied in fourth courses, which typically contain more advanced material, thus no areas of outstanding demand were identified and a score of 0 was given for this category.

## 5.3 Physics

The following is the list of subjects used in the physics subject comparison analysis.

**DP physics**[74]
Physics is a subject option from the DP sciences subject group, offered at both SL and HL. This subject has content that is common to both SL and HL, as well as AHL content that is featured only in the HL. Thus, the HL has greater breadth and depth than SL. This subject is intended to prepare students for university courses such as engineering, physics, and others requiring a strong science background. HL is suitable for those intending to pursue further study in an area requiring a strong background in physics.

**NGSS Physical Sciences**[75]
The NGSS high school standards apply from grades 9 to 12, and are split into Physical Sciences (PS), Life Sciences (LS), Earth and Space Sciences, and Engineering - with PS covering topics relating directly to physics alongside chemistry topics. The high school standards build upon the concepts taught and included in the middle school standards, so there is a natural progression from grade 8, the final year of middle school and high school where the content goes into greater depth and allows for further cross cutting themes to be explored across physical, life, and earth and space sciences. Key topic areas in PS include structure and the properties of matter, chemical reactions (more relevant to chemistry), forces and interactions, energy and waves and electromagnetic radiation.

### 5.3.1 Learning Outcomes – Physics

The learning outcome themes for physics were taken from the aims and assessment objectives of the DP sciences subject group, hence the themes are the same for physics, chemistry, and biology. The NGSS for grades 9-12 are made up of performance expectations which were developed using three elements – science and engineering practices, disciplinary core ideas, and cross-cutting concepts. For the analysis of learning outcomes, the science and engineering practices are the most relevant, however, the cross-cutting concepts and performance expectations are also reviewed to add context. It is important to note that the NGSS performance expectations used in the analysis apply across all grades 9-12, rather than individual years of study.

The following table demonstrates the learning outcome themes that were extracted from the DP sciences subject group and indicates if and where they were judged to have presence within the learning outcomes of the NGSS PS.

[74] International Baccalaureate. (2023). *Physics guide.* p.10.
[75] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Understanding the Standards.* [Understanding the Standards | Next Generation Science Standards (nextgenscience.org)]

*Table 15: Presence of the DP sciences learning outcome themes in the NGSS PS.*

| Themes extracted from the learning outcomes of the DP sciences subject group | | Presence in the NGSS |
|---|---|---|
| 1. Conceptual understanding and making connections | | Not present. No explicit reference to developing conceptual understanding or making connections. |
| 2. Use and application of knowledge, methods, tools, and techniques that characterise science | | Present. The science and engineering practices imply that students will have the knowledge and ability to apply it in various ways. Furthermore, some performance expectations explicitly refer to application of knowledge. |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, and synthesis) | | Present. This is a strong theme of the science and engineering practices. |
| 4. Skills for scientific investigation | | Present. This is a strong theme of the science and engineering practices. |
| 5. Development of technological skills | | Present. The science and engineering practices frequently refer to using technology. Furthermore, how science and technology influence each other, society and the environment is a theme present in the NGSS. |
| 6. Effective collaboration and communication | | Present. Collaboration is referred to in the context of carrying out investigations. The science and engineering practices also expect that students communicate in various formats. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Somewhat present. In the science and engineering practices, the impact of science is considered in context of carrying out investigations, and solving real-world problems is also stated. Also, how science, technology, society and the environment relate to one another is a theme in the NGSS, however only a limited number of performance expectations include this element. |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *This theme is well-evidenced in the learning outcomes of the NGSS.* | | *This theme is partially evidenced in the learning outcomes of the NGSS.* | | *This theme is not evident in the learning outcomes of the NGSS.* |

*<u>Presence of the DP's Learning Outcome Themes</u>*

The demonstration of understanding and application as a theme is well reflected across the NGSS topic areas. Although the NGSS performance expectations are predominantly skills-focused, it is clear that students would need to acquire significant fundamental knowledge and understanding of the key facts and underpinning theories and concepts in order to acquire the stated competencies. This is evident from the introductory statement of each performance expectation 'students who demonstrate understanding can:', implying that developing an understanding is a precursor to the application of knowledge in practice. The NGSS 'disciplinary core ideas' include the key content students are expected to understand. For example, in the topic on forces and interactions, core disciplinary ideas include forces and motion, types of interactions and definitions of energy. Furthermore, a large proportion of the

NGSS performance expectations involve applying knowledge across a range of different contexts and topic areas in the PS. Some make direct reference to 'apply', whereas others use other command words which similarly invoke the application of knowledge and skills. For example, 'Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict' clearly describes the skill of applying mathematical representations of physical laws to specific contexts that may involve problem solving implied by reference to 'prediction'.

However, there is no explicit reference to students developing conceptual understanding or making connections within physics or to other science disciplines and subjects. That said, the cross-cutting concepts are designed to help students understand core ideas, new phenomena, and science and engineering practices. Therefore, conceptual understanding and making connections are implicitly present in the design of the standards and likely to be needed to achieve the performance expectations

The science and engineering practices evidence numerous other DP themes. For example, 'Planning and carrying out investigation' aligns with the DP's themes of investigation skills, collaboration, and awareness of scientific implications – as it states that students should 'plan and conduct and investigations independently and collaboratively' and that this should be done in a 'safe and ethical manner including considerations of environmental, social, and personal impacts'. Furthermore, as well as providing detail on the design and implementation skills, the science and engineering practices also provide detail on the sub-skills involved in undertaking investigations. For instance, 'Obtaining, Evaluating and Communicating Information' details how students should be able to communicate scientific information and ideas in multiple formats. Additionally, the DP's theme of creative and critical thinking skills is strongly present in the science and engineering practices, which include these skills both in reference to investigations, and generally. Indeed, the science and engineering practices explain that students should be able to analyse data (using various techniques). 'Analysing and Interpreting Data' explains that students should be able to analyse data, construct evidence-based arguments, justify reasoning, evaluate and critique information, create and revise models, critically read scientific literature, and design solutions to real-world problems.

The DP's theme of developing technological skills is also present in the science and engineering practices, as they detail how students are expected to select and appropriately use technological tools for observing, measuring, recording, and analysing data – including for using models and performing statistical analysis. Furthermore, the ability to understand and consider the influence of science, engineering and technology on society and the environment as a whole is a cross-cutting theme within the NGSS. Therefore, it follows that there is some alignment with the DP's theme of the social and environmental implications of science. However, performance expectations which include this theme are few in the PS and LS standards.

*Other Themes in the NGSS*

A couple of outcome themes emerge as receiving greater emphasis in the NGSS when compared to the DP. The ability to use computational thinking is one area which appears to be more prominent in the NGSS performance expectations and in particular, the science and engineering practices. The performance expectations refer to using mathematical representations of physical models to solve problems, whilst the science and engineering practices make explicit reference to using computational simulations. Moreover, the science and engineering practices place more emphasis than is perhaps evident in the DP themes on understanding and applying scientific models. Indeed, in one such practice area students are expected to ’develop and use a model based on evidence to illustrate the relationships between systems or between components of a system’.

*Summary*

In summary, the performance expectations for the NGSS compare well overall to the DP themes, with similarities in the coverage of acquiring and applying knowledge, creative and critical thinking skills, investigation skills, use of technology, and effective communication and collaboration. However, it can be noted that, at times, themes are more present in the science and engineering practices and cross-cutting concept descriptions than the performance expectations themselves. A couple of themes, including computational thinking and the emphasis on scientific models, emerge as somewhat stronger in focus within the NGSS when compared to DP outcome themes, whilst developing conceptual understanding and considering ethical, social, environmental, and cultural implications of science are not covered in comparable depth in the NGSS.

### 5.3.2 Content – Physics

This section compares and contrasts the content of DP physics and the NGSS standards falling within the category of physics. In order to support visual comparison at-a-glance, the DP content is presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 17: DP physics content visualiser*[76]

| | | | | | |
|---|---|---|---|---|---|
| **A. Space, time and motion** | A.1 Kinematics | A.2 Forces and momentum | A.3 Work, energy and power | A.4 Rigid body mechanics (HL only) | A.5 Galilean and special relativity (HL only) |
| **B. The particulate nature of matter** | B.1 Thermal energy transfers | B.2 Greenhouse effect | B.3 Gas laws | B.4 Thermodynamics (HL only) | B.5 Current and circuits |
| **C. Wave behaviour** | C.1 Simple harmonic motion (SL + AHL) | C.2 Wave model | C.3 Wave phenomena (SL + AHL) | C.4 Standing waves and resonance | C.5 Doppler effect (SL + AHL) |
| **D. Fields** | D.1 Gravitational fields | D.2 Electric and magnetic fields | D.3 Motion in electromagnetic fields | D.4 Induction (HL only) | |
| **E. Nuclear and quantum physics** | E.1 Structure of the atom (SL + AHL) | E.2 Quantum physics (HL only) | E.3 Radioactive decay (SL + AHL) | E.4 Fission | E.5 Fusion and stars |
| **Experimental programme** | Practical work | Collaborative sciences project | Scientific investigation | | |

[76] '(HL only)' and '(SL + AHL)' are used to flag, respectively, topics only taught at HL and topics taught at both SL and HL, but which also feature additional higher level content.

*Figure 18: NGSS PS (physics focus) content visualiser*[77]

| | | | | | |
|---|---|---|---|---|---|
| **Core** | PS1: Matter and its Interactions | | | PS1.C: Nuclear Processes | |
| | PS2: Motion and Stability: Forces and Interactions | PS2.A: Forces and Motion | PS2.B: Types of Interactions | PS2.C: Stability and Instability in Physical Systems | |
| | PS3: Energy | PS3.A: Definitions of Energy | PS3.B: Conservation of Energy and Energy Transfer | PS3.C: Relationship Between Energy and Forces | PS3.D: Energy in Chemical Processes and Everyday Life |
| | PS4: Waves and their Applications in Technologies for Information Transfer | PS4.A: Wave Properties | PS4.B: Electromagnetic Radiation | PS4.C: Information Technologies and Instrumentation | |
| **Crosscutting concepts** | Patterns | | | | |
| | Cause and effect: Mechanism and explanation | | | | |
| | Scale, proportion, and quantity | | | | |
| | Systems and system models | | | | |
| | Energy and matter: Flows, cycles, and conservation | | | | |
| | Structure and function | | | | |
| | Stability and change | | | | |
| **Scientific and Engineering Practices** | Asking questions (for science) and defining problems (for engineering) | | | | |
| | Developing and using models | | | | |
| | Planning and carrying out investigations | | | | |
| | Analyzing and interpreting data | | | | |
| | Using mathematics and computational thinking | | | | |
| | Constructing explanations (for science) and designing solutions (for engineering) | | | | |
| | Engaging in argument from evidence | | | | |
| | Obtaining, evaluating, and communicating information | | | | |

[77] NB: only physics-focused units of work from the physical sciences standards have been included. Units pertaining to other scientific disciplines are included in the relevant subject's section. For example, PS1.A and PS1.B relate to chemistry and therefore do not appear in this figure.

*Structure*
As can be seen in the content visualisers above, the DP has a more detailed and comprehensive syllabus than the NGSS course, suggesting that students following the DP will have a more standardised experience overall. In the DP, there is a suggested amount of time to cover each topic over the two-year course and there is detailed information on the sub-topics to cover. The NGSS framework, on the other hand, offers considerably less detail and does not stipulate a set amount of time for each topic (Appendix K[78]), leaving teachers/schools with the flexibility to progress through content at the pace best suited to their students. The content set out in the NGSS framework is designed for students in high school (four years of study) to continue to develop their understanding of the four core ideas in the PS but is intended to leave room for expanded study in upper-level high school courses. The NGSS framework is more open to interpretation – i.e. content statements are very broad and there will likely be significant variation in how they are delivered and the depth in which they are covered. This variation may also be magnified by the fact that there are no standardised external assessments.

In terms of study pathways, the DP physics provides two routes for learning: standard level (SL) and higher level (HL), with the HL content being more conceptually demanding and explored in greater depth. In contrast, only one pathway is outlined in the NGSS PS, with students studying all high school science topics outlined. Moreover, even though it is stated that the NGSS should prepare students for university and careers, it is recommended in Appendix K[79] that students particularly interested in STEM might need to take further courses in preparation for university.

Both the NGSS and the DP allow for freedom in choice when it comes to teaching order of subjects and both allow for practical demonstrations, modelling, and links to real world scenarios. The NGSS framework has a strong emphasis on disciplinary core ideas and cross cutting concepts which run through K-12, serving as anchors to student learning and helping them to assimilate new ideas. The DP has a general focus on developing the learner profile, and a specific focus on developing relevant 'tools' and 'inquiry' skills in physics and other sciences, making topic-level linkages to approaches to learning, the nature of science, and study skills.

Though both the DP and NGSS make references to practical work, the DP is more explicit about this, assigning a combined 40 hours to the collaborative science project and Internal Assessment (IA) scientific investigation. In contrast, the NGSS simply reference inquiry skills in the science and engineering practice performance expectations, with students being expected to 'Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles' in the topic on the Structure and Properties of Matter.

[78] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Appendix K. Model Course Mapping in Middle and High School for the Next Generation Science Standards*. https://www.nextgenscience.org/sites/default/files/Appendix%20K_Revised%208.30.13.pdf
[79] Ibid.

Overall, despite some potential structural similarities, the DP physics course has a significantly more defined content structure than the NGSS, with student experiences of those studying the latter likely varying significantly.

*<u>Content Alignment</u>*

To complement the analysis on content alignment, the figure below represents a simplified summary of the NGSS's content alignment, at topic-level, with DP physics (SL and HL).

*Figure 19: Summary of the content alignment between the DP physics topics and the NGSS PS (physics) standards.*

| DP physics subtopics | Presence of SL content in the NGSS PS | Presence of AHL content in the NGSS PS |
|---|---|---|
| **A. Space, time and motion** | | |
| A.1 Kinematics | | N/A |
| A.2 Forces and momentum | | N/A |
| A.3 Work, energy and power | | N/A |
| A.4 Rigid body mechanics | N/A | |
| A.5 Galilean and special relativity | N/A | |
| **B. The particulate nature of matter** | | |
| B.1 Thermal energy transfers | | N/A |
| B.2 Greenhouse effect | | N/A |
| B.3 Gas laws | | N/A |
| B.4 Thermodynamics | N/A | |
| B.5 Current and circuits | | N/A |
| **C. Wave behaviour** | | |
| C.1 Simple harmonic motion | | |
| C.2 Wave model | | N/A |
| C.3 Wave phenomena | | |
| C.4 Standing waves and resonance | | N/A |
| C.5 Doppler effect | | |
| **D. Fields** | | |
| D.1 Gravitational fields | | |
| D.2 Electric and magnetic fields | | |
| D.3 Motion in electromagnetic fields | | N/A |
| D.4 Induction | N/A | |
| **E. Nuclear and quantum physics** | | |
| E.1 Structure of the atom | | |
| E.2 Quantum physics | N/A | |
| E.3 Radioactive decay | | |
| E.4 Fission | | N/A |
| E.5 Fusion and stars | | N/A |
| Experimental programme | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *There is strong presence of this topic in the NGSS* | | *There is partial presence of this topics in the NGSS* | | *There is little or no presence of this topic in the NGSS* |

As can be seen in the figures above, the topic coverage for NGSS PS has some alignment with all the DP SL topics, such as 'Space, time and motion'; 'The particulate nature of matter'; 'Wave behaviour'; 'Fields'; and 'Nuclear and quantum physics'.

In particular, the NGSS include good coverage of the DP SL sub-topics of forces and momentum, wave model, gravitational fields, and work, energy and power, though the mathematical requirements in the latter are not specified. In the sub-topic of kinematics, too, the NGSS feature scope to cover the same content as the DP, except for projectiles – which are not covered in the former – and the mathematical requirements overall, which are also unclear.

Additionally, various other DP SL sub-topic areas – thermal energy transfers; greenhouse effect; simple harmonic motion; wave phenomenon; electric and magnetic fields; structure of the atom; fission; fusion and stars; and radioactive decay – are also featured in the NGSS, though only partially. In simple harmonic motion, for instance, the NGSS make no specific reference to mass-spring and pendulum, which are explicitly mentioned in the DP. As to the sub-topic of radioactive decay, the NGSS specifically state that no calculation of energy release is needed, while this is an explicit requirement in the DP.

There are also a few significant gaps in coverage of SL content by the NGSS framework – topic B.5 Current and Circuits is not covered in NGSS, nor are Gas Laws (i.e. DP topic B.3).

Notably, most of the DP HL content is not covered in the NGSS framework; the only potential exception being the AHL in the DP D.1 Gravitational Fields sub-topic, where the NGSS may offer scope to cover some of this content.

The NGSS framework does state that there are opportunities to extend learning and the vagueness of the statements could give opportunities to explore more complex content; however, in the assessment boundaries for a number of subject statements it can be seen that some content which is covered in DP is expressly excluded in the NGSS framework, for example, 'HS-PS4-3…[Assessment Boundary: Assessment does not include using quantum theory.]'. Moreover, it is notable that the mathematical demand is much greater in the DP course. Although, at times, some NGSS statements could be interpreted to include some mathematical concepts, the depth and breadth expected are not clear and open to interpretation. By contrast, DP students are expressly expected to use a much greater number of mathematical expressions to explain phenomena in the DP.

Overall, although the NGSS content was found to have some alignment across all DP physics topics, the DP has both greater depth and greater breadth than the NGSS framework.

*Table 16: NGSS content which is not covered by DP physics*

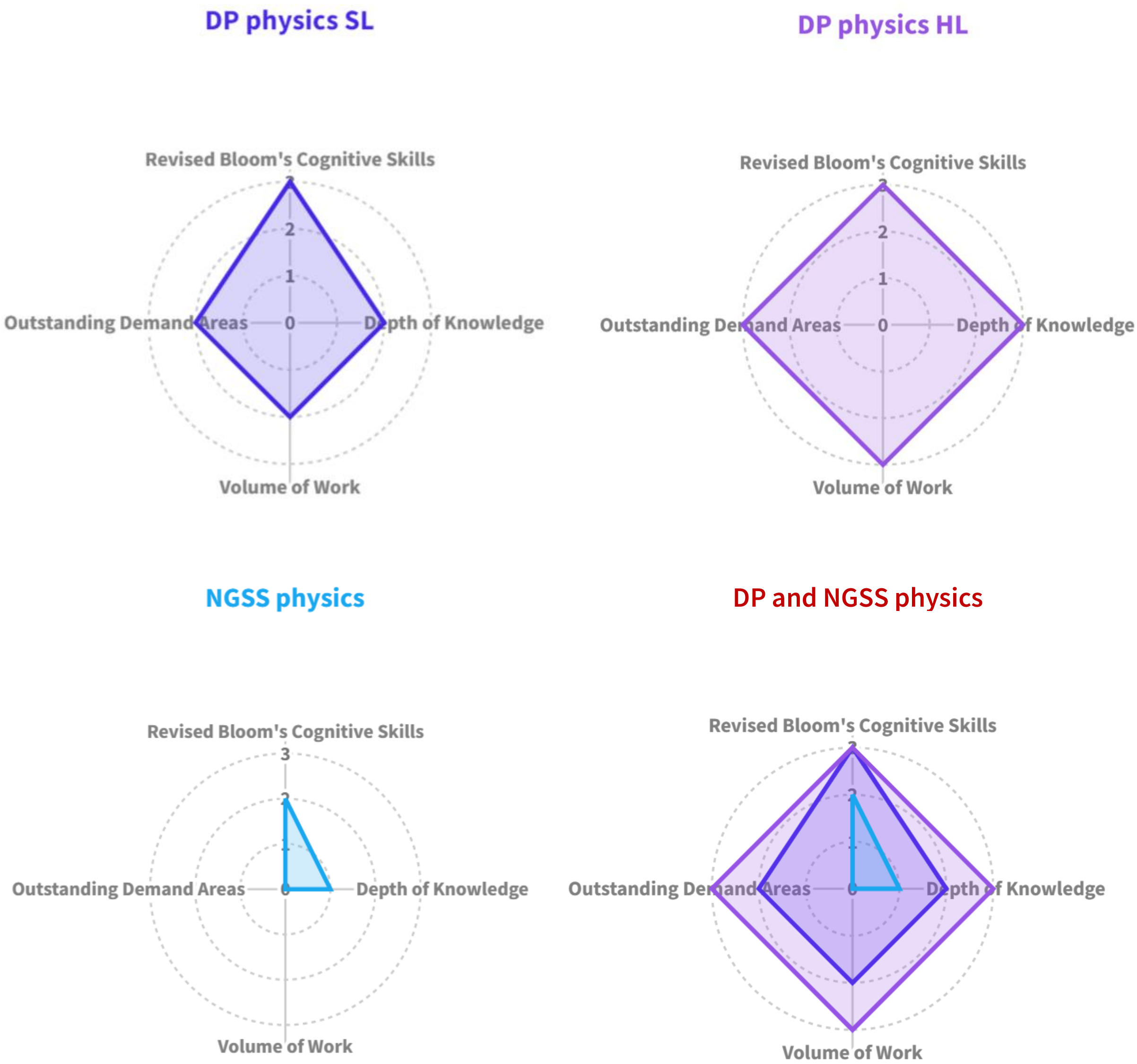
| Significant NGSS content not included in the DP physics* |
| --- |
| ◦ There is no significant content in the NGSS not covered by DP physics. |

*Significant content does not include topics which are typical to learning prior to upper secondary

### 5.3.3 Demand – Physics

The DP and the NGSS curricula were analysed using the same demand tool in order to create a demand profile for DP physics SL, DP physics HL, and the NGSS Physical Science standards. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles superimposed in one place, enabling immediate visual comparison.

*Figure 20: Visual representations of subject demand*




The panel of experts carried out a detailed analysis of each course and reached a consensus on the scores shown in the profiles above. The following points were particularly important within the panel discussion:

- Regarding the scores for **Bloom's Cognitive Skills:**
    - DP physics has the same learning outcomes for both SL and HL, meaning that these scores are the same. These were judged to merit a score of 3 due to the high levels of conceptual and critical thinking, critical awareness and elements of synthesis and creation present in the majority of course aims and assessment objective 3.
    - For the NGSS, a Bloom's score of 2 was deemed appropriate given a predominant focus on knowledge acquisition and application, with some presence (though limited) of higher-order thinking skills, such as analysis and interpretation of data, and emphasis on cross-curricular links. It was noted by the panel that there are

good examples of individual states providing more detail on how to apply the standards effectively, though this detail is absent from the NGSS themselves.

- Regarding the scores for **Depth of Knowledge:**
  - DP physics SL was deemed to merit a score of 2 for Depth of Knowledge due to the mathematical pre-requisite skills and competences required to access the course, as well as the moderate to high level of cognitive complexity of the knowledge that students are expected to acquire. As to the HL course, the greater depth and additional opportunities provided for extended thinking in the additional higher level option topics pushed the score to a 3.
  - For the NGSS, the depth of knowledge was seen to meet a score of 1 due to the key pre-requisite requirements and some reference to calculations and analysis, though the level to which these are applied is unclear from the standards themselves.

- Regarding the scores for **Volume of Work:**
  - DP physics SL was judged to comprise a moderate-heavy workload (a score of 2) as students are exposed to multiple physics topics, with each topic being allocated a standard to short amount of time. The volume demands of the HL course, on the other hand, were found to be sufficient to meet a score of 3 as, even though the proportion of topics studied in the same amount of time is smaller, these topics are covered in great depth and with a focus on application.
  - In contrast, the NGSS received a score of 0 for volume of work due to the apparently light depth and detail of knowledge and skills evidenced in the documentation. However, it was noted that the real breadth and depth of content, as well as time allocation per theme, may vary significantly from state to state or even school to school, depending on how the standards are applied.

- Regarding the scores for **Outstanding Areas of Subject Demand:**
  - For the DP physics SL course (awarded a score of 2), the AI scientific investigation research project that students need to undertake, the linking questions outlined in the syllabus, and the collaborative sciences project were all considered to be stretch areas. In addition to the latter, the HL course features additional higher levels topics which were deemed to include additional areas of stretch, meriting a score of 3.
  - As to the NGSS, a score of 0 was awarded as no clear areas of outstanding demand were identified – it was noted that the emphasis on cross-curricular linkages could provide opportunities for potential stretch, but that it was not possible to clearly infer this from the NGSS documentation.

## 5.4 Chemistry

The following is the list of subjects used in the chemistry subject comparison analysis.

**DP chemistry**[80]

[80] International Baccalaureate. (2023). *Chemistry guide.*

Chemistry is a subject option offered within the DP sciences subject group, at both SL and HL. This subject has content that is common to both SL and HL, as well as AHL content that is featured only in the HL. Thus, the HL has greater breadth and depth than SL. This subject is designed to prepare students for university courses such as medicine, biological science and environmental science. HL is suitable for those intending to pursue further study in an area requiring a strong background in chemistry.

**NGSS Physical Sciences**[81]
The NGSS high school standards apply from grades 9 to 12 and are split into Physical Sciences (PS), Life Sciences (LS), Earth and Space Sciences, and Engineering - with PS covering topics relating directly to physics alongside chemistry topics. The high school standards build upon the concepts taught and included in the middle school standards, so there is a natural progression from grade 8, the final year of middle school and high school where the content goes into greater depth and allows for further cross cutting themes to be explored across physical, life and earth and space sciences. NGSS PS include topics on chemistry, which overlap in some areas with those relevant to physics. These topics of direct relevance to chemistry include the structure and properties of matter and in particular, chemical reactions.

### 5.4.1 Learning Outcomes – Chemistry

The learning outcome themes for chemistry were taken from the aims and assessment objectives of the DP sciences subject group, hence the themes are the same for physics, chemistry, and biology. The NGSS for grades 9-12 are made up of performance expectations, which were developed using three elements – science and engineering practices, disciplinary core ideas, and cross-cutting concepts. For the analysis of learning outcomes, the science and engineering practices are the most relevant, however the cross-cutting concepts and performance expectations are also reviewed to add context. It is important to note that the NGSS performance expectations used in the analysis apply across all grades 9-12, rather than individual years of study.

Since the most relevant comparison points – the science and engineering practices and cross-cutting concepts – are the same for both the PS and LS in the NGSS, then the learning outcome analysis will be the same for chemistry as it is for physics. Therefore, this section will include the summary table again, followed by a shortened overview of the findings. More details on the comparison of learning outcomes can be found in section 5.3.1 Learning Outcomes – Physics.

The following table demonstrates the learning outcome themes that were extracted from the DP sciences subject group and indicates if and where they were judged to have presence within the learning outcomes of the NGSS PS.

[81] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Understanding the Standards.*

*Table 17: Presence of the DP sciences subject group learning outcome themes in the NGSS PS*

| Themes extracted from the learning outcomes of the DP sciences subject group | Presence in the NGSS | |
|---|---|---|
| 1. Conceptual understanding and making connections | | Not present. No explicit reference to developing conceptual understanding or making connections. |
| 2. Use and application of knowledge, methods, tools, and techniques that characterise science | | Present. The science and engineering practices imply that students will have the knowledge and ability to apply it in various ways. Furthermore, some performance expectations explicitly refer to application of knowledge. |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, and synthesis) | | Present. This is a strong theme of the science and engineering practices. |
| 4. Skills for scientific inquiry | | Present. This is a strong theme of the science and engineering practices. |
| 5. Development of technological skills | | Present. The science and engineering practices frequently refer to using technology. Furthermore, how science and technology influence each other, society and the environment is a theme present in the NGSS. |
| 6. Effective collaboration and communication | | Present. Collaboration is referred to in the context of carrying out investigations. The science and engineering practices also expect that students are able to communicate in various formats. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Somewhat present. In the science and engineering practices, the impact of science is considered in context of carrying out investigations, and solving real-world problems is also stated. Also, how science, technology, society and the environment relate to one another is a theme in the NGSS, however only a limited number of performance expectations include this element. |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *This theme is well-evidenced in the learning outcomes of the NGSS.* | | *This theme is partially evidenced in the learning outcomes of the NGSS.* | | *This theme is not evident in the learning outcomes of the NGSS.* |

*Summary*

As with physics, learning outcomes from the NGSS PS standards compare well to the themes extracted from the DP's sciences subject group. Acquiring and applying knowledge of ideas, theories and concepts in chemistry is evident across a number of the performance expectations in the topic areas relevant to chemistry in the NGSS PS. For example, in the topic on chemical reactions, students are expected to 'Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties'. Furthermore, application of scientific knowledge is also indicated by a range of NGSS performance expectations, particularly those that specify the command words 'use', 'construct' and ‘apply’. However, conceptual understanding and making connections is not explicitly referenced the NGSS – though will likely be needed to achieve the performance expectations.

Furthermore, the science and engineering practices align with numerous DP themes. Indeed, ‘Planning and conducting investigations’, ‘Analysing and interpreting data’, ‘Constructing explanations and designing solutions’, and ‘Engaging with argument from evidence’ all align with the DP’s themes of developing scientific inquiry skills and using creative and critical thinking. Another DP theme, effective communication and collaboration, is addressed in ‘Obtaining, evaluation and communicating information’ and ‘Planning and conducting investigations. Reference to using technological tools appears in several practices, hence the DP’s theme of developing technical skills is also satisfied. As well as conceptual understanding, a lesser present theme is that of the ethical, environmental, economic, cultural and social impact of science. Though the relationship between science, technology, society and the environment is a theme in the NGSS, it is not present in many performance expectations.

Finally, the NGSS learning outcomes place more emphasis on computational thinking and using and applying models than the DP does in its learning outcomes.

### 5.4.2 Content – Chemistry

This section compares and contrasts the content of DP chemistry and the NGSS falling within the category of chemistry. In order to support visual comparison at-a-glance, the DP content is presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 21: DP chemistry content visualiser*[82]

| | | | | | | |
|---|---|---|---|---|---|---|
| **Structure** | **Structure 1. Models of the particulate nature of matter** | Structure 1.1 – Introduction to the particulate nature of matter | Structure 1.2 – The nuclear atom (SL + AHL) | Structure 1.3 – Electron configurations (SL + AHL) | Structure 1.4 – Counting particles by mass: The mole | Structure 1.5 – Ideal gases |
| | **Structure 2. Models of bonding and structure** | Structure 2.1 – The ionic model | Structure 2.2 – The covalent model (SL + AHL) | Structure 2.3 – The metallic model (SL + AHL) | Structure 2.4 – From models to materials (SL + AHL) | |
| | **Structure 3. Classification of matter** | Structure 3.1 – The periodic table: Classification of elements (SL + AHL) | Structure 3.2 – Functional groups: Classification of organic Compounds (SL + AHL) | | | |
| **Reactivity** | **Reactivity 1. What drives chemical reactions?** | Reactivity 1.1 – Measuring enthalpy changes | Reactivity 1.2 – Energy cycles in reactions (SL + AHL) | Reactivity 1.3 – Energy fromfuels | Reactivity 1.4 – Entropy and spontaneity (HL only) | |
| | **Reactivity 2. How much, how fast and how far?** | Reactivity 2.1 – How much? The amount of chemical change | Reactivity 2.2 – How fast? The rate of chemical change (SL + AHL) | Reactivity 2.3 – How far? The extent of chemical change (SL + AHL) | | |
| | **Reactivity 3. What are the mechanisms of chemical change?** | Reactivity 3.1 – Proton transfer reactions (includes AHL) | Reactivity 3.2 – Electron transfer reactions (SL + AHL) | Reactivity 3.3 – Electron sharing reactions | Reactivity 3.4 – Electron-pair sharing reactions (SL + AHL) | |
| **Experimental programme** | **Practical work** | Collaborative sciences project | Scientific investigation | | | |

[82] '(HL only)' and '(SL + AHL)' are used to flag, respectively, topics only taught at HL and topics taught at both SL and HL, but which also feature additional higher level content.

*Figure 22: NGSS PS (chemistry focus) content visualiser*[83]

| | | | | | |
|---|---|---|---|---|---|
| **Core** | **PS1: Matter and its Interactions** | PS1.A: Structure and Properties of Matter | PS1.B: Chemical Reactions | PS1.C: Nuclear Processes | |
| | **PS2: Motion and Stability: Forces and Interactions** | | | | |
| | **PS3: Energy** | PS3.A: Definitions of Energy | PS3.B: Conservation of Energy and Energy Transfer | | PS3.D: Energy in Chemical Processes and Everyday Life |
| | **PS4: Waves and their Applications in Technologies for Information Transfer** | | | PS4.C: Information Technologies and Instrumentation | |
| **Crosscutting concepts** | **Patterns** | | | | |
| | **Cause and effect: Mechanism and explanation** | | | | |
| | **Scale, proportion, and quantity** | | | | |
| | **Systems and system models** | | | | |
| | **Energy and matter: Flows, cycles, and conservation** | | | | |
| | **Structure and function** | | | | |
| | **Stability and change** | | | | |
| **Scientific and Engineering Practices** | **Asking questions (for science) and defining problems (for engineering)** | | | | |
| | **Developing and using models** | | | | |
| | **Planning and carrying out investigations** | | | | |
| | **Analyzing and interpreting data** | | | | |
| | **Using mathematics and computational thinking** | | | | |
| | **Constructing explanations (for science) and designing solutions (for engineering)** | | | | |
| | **Engaging in argument from evidence** | | | | |
| | **Obtaining, evaluating, and communicating information** | | | | |

[83] NB: only chemistry-focused units of work from the physical sciences standards have been included. Units pertaining to other scientific disciplines are included in the relevant subject's section. For example, PS2 and PS3.C relate to physics and therefore do not appear in this figure.

*Structure*

Unlike the DP chemistry course, the NGSS chemistry topics are integrated into the physical science standards, which cover both chemistry and physics topics. Moreover, the content is spread across four grade levels (9-12), as opposed to the two years for the DP chemistry course. In the NGSS there is one pathway, with students studying all high school science topics outlined. In contrast, the DP provides two routes for learning; standard level (SL) and higher level (HL), with the HL chemistry content being more conceptually demanding and explored in greater depth.

The structure of DP chemistry is intended to promote conceptual teaching and learning, with the course being organised around two overarching concepts – structure and reactivity. The order of the syllabus is, thus, designed to show that structure leads to reactivity, which then alters structures. Teachers and students can use the guiding inquiry questions provided or design their own to lead the learning within each subtopic. The NGSS science curricula have been designed to allow standards to be taught in any order within the high school grade levels. In this sense, both programmes have in-built flexibility.

There are some clear structural differences between the DP and NGSS that stem from their overarching design principles. For example, the DP highlights clear links to approaches to learning, the nature of science, and study skills in chemistry at topic level. The NGSS, on the other hand, are more focused on the subject-specific objectives which are required to be met. While the NGSS do make reference to 'connections to the nature of science', they do so in a more general way rather than being topic-specific, which could limit the impact of this strand within teaching and learning.

Like DP physics, the DP chemistry course offers more opportunities for practical work, through 40 assigned hours comprising the collaborative science project and IA scientific investigation. The DP chemistry course also stipulates that students should show awareness of the purpose and practice of 13 chemistry techniques, outlined in Tool 1: Experimental techniques. In contrast, the NGSS contain much less emphasis on practical chemistry techniques, making explicit reference to only two of the 13 techniques required in the DP: melting point determination and molecular modelling.

Overall, despite some structural similarities, the DP chemistry course has a significantly more defined content structure than the NGSS, with student experiences of those studying the latter likely varying significantly.

*Content Alignment*

To complement the analysis on content alignment, the figure below represents a simplified summary of the NGSS's content alignment, at topic-level, with DP chemistry (SL and HL).

*Figure 23: Summary of the content alignment between the DP chemistry topics and the NGSS PS (chemistry) standards.*

| DP chemistry topics | Presence of SL content in the NGSS | Presence of AHL content in the NGSS |
|---|---|---|
| Structure 1. Models of the particulate nature of matter | | |
| Structure 1.1 – Introduction to the particulate nature of matter | | N/A |

| | | |
|---|---|---|
| Structure 1.2 – The nuclear atom | | |
| Structure 1.3 – Electron configurations | | |
| Structure 1.4 – Counting principles by mass: The mole | | N/A |
| Structure 1.5 – Ideal gases | | N/A |
| Structure 2. Models of bonding and structure | | |
| Structure 2.1 – The ionic model | | N/A |
| Structure 2.2 – The covalent model | | |
| Structure 2.3 – The metallic model | | |
| Structure 2.4 – From models to materials | | |
| Structure 3. Classification of matter | | |
| Structure 3.1 – The periodic table: Classification of elements | | |
| Structure 3.2 – Functional groups: Classification of organic compounds | | |
| Reactivity 1. What drives chemical reactions? | | |
| Reactivity 1.1 – Measuring enthalpy changes | | N/A |
| Reactivity 1.2 – Energy cycles in reactions | | |
| Reactivity 1.3 – Energy from fuels | | N/A |
| Reactivity 1.4 – Entropy and spontaneity (AHL only) | N/A | |
| Reactivity 2. How much, how fast and how far? | | |
| Reactivity 2.1 – How much? The amount of chemical change | | N/A |
| Reactivity 2.2 – How fast? The rate of chemical change | | |
| Reactivity 2.3 – How far? The extent of chemical change | | |
| Reactivity 3. What are the mechanisms of chemical change? | | |
| Reactivity 3.1 – Proton transfer reactions | | |
| Reactivity 3.2 – Electron transfer reactions | | |
| Reactivity 3.3 – Electron sharing reactions | | N/A |
| Reactivity 3.4 – Electron-pair sharing reactions | | |
| Experimental programme | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *There is strong presence of this topic in the NGSS* | | *There is partial presence of this topic in the NGSS* | | *There is little or no presence of this topic in the NGSS* |

As illustrated by the tables above, the depth and breadth of content for chemistry in the DP, both at SL and HL, exceed that of the chemistry topics in the NGSS PS. Across all NGSS, only two out of sixteen units studied focus on chemistry topics, a very small number which likely results in very limited time being dedicated to chemistry overall.

There is, however, some partial coverage of some DP chemistry topics in the NGSS, with the latter partially covering approximately three-quarters of the SL chemistry course. Topics covered include periodicity, the mole concept, bonding, rates of reaction, and the nuclear atom. The generous time allocation and broad learning objectives provide flexibility for teachers to extend learning in some topics if they choose to do so. However, the framework provides clear assessment boundaries, which teachers should not exceed. An example of this is within the sub-topic of equilibrium, where the assessment boundary states equilibrium constants and concentrations should not be calculated. In contrast, DP chemistry encourages sub-topics to be explored in greater depth and poses no limit to the scope of the curriculum.

Overall, there is limited alignment between the DP and NGSS, with several key DP chemistry sub-topics being fully absent from the NGSS PS, including: electron configurations, ideal gases, classification of organic compounds, proton transfer, electron sharing, and transfer reactions. Additionally, some of the SL sub-topics are covered in less depth, such as concentrations in Structure 1.4, shapes of molecules and bond polarity in Structure 2.2, and both electron transfers and electrochemical cells in Structure 3.2 (the latter not being referenced anywhere in the NGSS).

*Table 18: NGSS content which is not covered by DP chemistry*

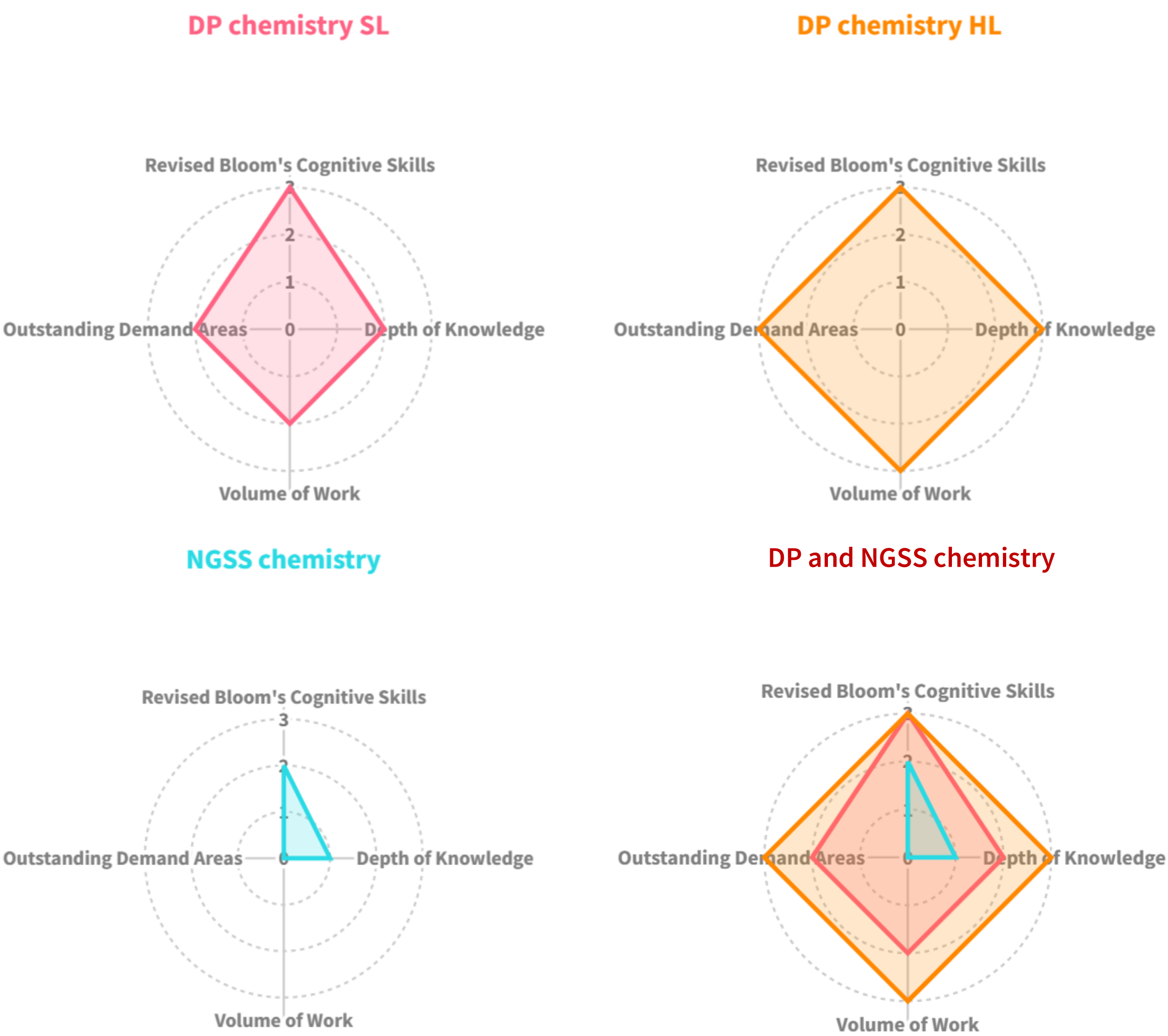
| Significant NGSS content which is not included in DP chemistry* |
|---|
| ○ None – there is a very limited number of chemistry topics covered in the NGSS. |

* Significant content does not include topics which are typically studied *prior* to upper secondary

### 5.4.3 Demand – Chemistry

The DP and the NGSS curricula were analysed using the same demand tool in order to create a demand profile for DP chemistry SL, DP chemistry HL, and the NGSS Physical Sciences standards. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles superimposed in one place, enabling immediate visual comparison.

*Figure 24: Visual representations of subject demand*



The panel of experts carried out a detailed analysis of each course and reached a consensus on the scores shown in the profiles above. The following points were particularly important within the panel discussion:

- Regarding the scores for **Bloom's Cognitive Skills:**
  - DP chemistry has the same learning outcomes for both SL and HL, meaning that these scores are the same. These were judged to merit a score of 3 due to the high levels of critical thinking, critical awareness and elements of synthesis and creation present in the majority of aims and assessment objective 3.
  - For the NGSS, a Bloom's score of 2 was deemed appropriate given a predominant focus on knowledge acquisition and application, with some presence (though limited) of higher-order thinking skills, such as analysis and interpretation of data, and emphasis on cross-curricular links. It was noted by the panel that there are good examples of individual states providing more detail on how to apply the standards effectively, though this detail is absent from the NGSS themselves.

- Regarding the scores for **Depth of Knowledge:**
  - DP chemistry SL was deemed to merit a score of 2 for Depth of Knowledge due to the mathematical pre-requisite skills and competences required to access the course, as well as the moderate to high level of cognitive complexity of the knowledge that students are expected to acquire. As to the HL course, the greater depth and additional opportunities provided for extended thinking in the additional higher level option topics pushed the score to a 3.
  - For the NGSS, the depth of knowledge was seen to meet a score of 1 due to the key pre-requisite requirements and some reference to calculations and analysis, though the level to which these are applied is unclear from the standards themselves.

- Regarding the scores for **Volume of Work:**
  - DP chemistry SL was judged to comprise a moderate-heavy workload (a score of 2) as students are exposed to various chemistry topics, with each topic being allocated a standard to short time amount of time. The volume demands of the HL course, on the other hand, were found to be sufficient to meet a score of 3 – even though the number of topics per hour is smaller, these topics are covered in great depth and with a focus on application.
  - In contrast, the NGSS received a score of 0 for volume of work due to the apparently light depth and detail of knowledge and skills evidenced in the documentation. However, it was noted that the real breadth and depth of content, as well as time allocation per theme, may vary significantly from state to state or even school to school, depending on how the standards are applied.

- Regarding the scores for **Outstanding Areas of Subject Demand:**
  - For the DP chemistry SL course (awarded a score of 2), the IA individual investigation research project that students need to undertake, the linking questions outlined in the syllabus and the collaborative sciences project were deemed to constitute areas of stretch. In addition to the latter, the HL course features additional higher levels topics which were deemed to include additional areas of stretch, meriting a score of 3.

- As to the NGSS, a score of 0 was awarded as no clear areas of outstanding demand were identified – it was noted that the emphasis on cross-curricular linkages could provide opportunities for potential stretch, but that it was not possible to clearly infer this from the NGSS documentation.

## 5.5 Biology

The following is the list of subjects used in the biology subject comparison analysis.

**DP biology**[84]
Biology is a subject option within the DP sciences subject group, offered at both SL and HL. This subject offers content that is common to both SL and HL, as well as AHL content for HL. Thus, HL has greater breadth and depth than SL. This subject is designed to prepare students for university courses such as biology, medicine, dentistry, and biomedical engineering. HL is suitable for those intending to pursue further study in an area requiring a strong background in biology.

**NGSS Life Sciences**[85]
The NGSS high school standards apply from grades 9 to 12 and are split into Physical Sciences (PS), Life Sciences (LS), Earth and Spaces Sciences, and Engineering. LS cover topics relating to biology, including a number of those covered in the DP biology. As in the NGSS PS, the high school LS standards build upon the concepts taught and included in the middle school standards, so there is a natural progression from grade 8, the final year of middle school and high school where the content goes into greater depth and allows for further cross cutting themes to be explored across topic areas in science. The LS comprise of five main topic areas including structure and function, inheritance and variation of traits, matter and energy in organisms and ecosystems, interdependent relationships in ecosystems, and natural selection and evolution.

### 5.5.1 Learning Outcomes – Biology

The learning outcome themes for biology were extracted from the aims and assessment objectives of the DP sciences subject group, hence the themes are the same for physics, chemistry, and biology. The NGSS for grades 9-12 are made up of performance expectations which were developed using three elements – science and engineering practices, disciplinary core ideas, and cross-cutting concepts. For the analysis of learning outcomes, the science and engineering practices are the most relevant, however the cross-cutting concepts and performance expectations are also reviewed to add context. It is important to note that the NGSS performance expectations used in the analysis apply across all grades 9-12, rather than individual years of study.

Since the most relevant comparison points – the science and engineering practices and cross-cutting concepts – are the same for both the PS and LS in the NGSS, then the learning outcome analysis will be the same for biology as it is for physics. Therefore, this section will include the summary table again, followed by a shortened overview of the findings. More details on the comparison of learning outcomes can be found in section 5.3.1 Learning Outcomes – Physics.

[84] International Baccalaureate. (2023). *Biology guide*.
[85] NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Understanding the Standards.*

The following table demonstrates the learning outcome themes that were extracted from the DP sciences subject group and indicates if and where they were judged to have presence within the learning outcomes of the NGSS LS.

*Table 19: Presence of the DP sciences learning outcome themes in the NGSS LS learning outcomes*

| **Themes extracted from the learning outcomes of the DP sciences subject group** | | **Presence in the NGSS** |
|---|---|---|
| 1. Conceptual understanding and making connections | | Not present. No explicit reference to developing conceptual understanding or making connections. |
| 2. Use and application of knowledge, methods, tools, and techniques that characterise science | | Present. The science and engineering practices imply that students will have the knowledge and ability to apply it in various ways. Furthermore, some performance expectations explicitly refer to application of knowledge. |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, and synthesis) | | Present. This is a strong theme of the science and engineering practices. |
| 4. Skills for scientific inquiry | | Present. This is a strong theme of the science and engineering practices. |
| 5. Development of technological skills | | Present. The science and engineering practices frequently refer to using technology. Furthermore, how science and technology influence each other, society and the environment is a theme present in the NGSS. |
| 6. Effective collaboration and communication | | Present. Collaboration is referred to in the context of carrying out investigations. The science and engineering practices also expect that students are able to communicate in various formats. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Somewhat present. In the science and engineering practices, the impact of science is considered in context of carrying out investigations, and solving real-world problems is also stated. Also, how science, technology, society and the environment relate to one another is a theme in the NGSS, however only a limited number of performance expectations include this element. |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *This theme is well-evidenced in the learning outcomes of the NGSS.* | | *This theme is partially evidenced in the learning outcomes of the NGSS.* | | *This theme is not evident in the learning outcomes of the NGSS.* |

<u>Summary</u>

As with physics and chemistry, learning outcomes from the NGSS LS standards compare well to the themes extracted from the DP's sciences subject group. Acquiring and applying knowledge of ideas, theories and concepts in biology is evident across a number of the performance expectations in the topic areas relevant to biology in the NGSS LS. For example, students are expected to 'Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy' and 'Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population'. Generally, application of scientific knowledge is indicated by a range of NGSS performance expectations, particularly those that specify the command words 'use', 'construct' and 'apply'. However, conceptual understanding and making connections is not explicitly referenced in the NGSS – though will likely be needed to achieve the performance expectations

Furthermore, the science and engineering practices align with numerous DP themes. Indeed, 'Planning and conducting investigations', 'Analysing and interpreting data', 'Constructing explanations and designing solutions', and 'Engaging with argument from evidence' all align with the DP's themes of developing scientific inquiry skills and using creative and critical thinking. Another DP theme, effective communication and collaboration, is addressed in 'Obtaining, evaluation and communicating information' and 'Planning and conducting investigations'. Reference to using technological tools appears in several practices, hence the DP's theme of developing technical skills is also satisfied. As well as conceptual understanding, a lesser present theme is that of the ethical, environmental, economic, cultural and social impact of science. Though the relationship between science, technology, society and the environment is a theme in the NGSS, it is not present in many performance expectations in the LS. However, in the introduction to the LS standards, it is stated that students develop an understanding of the ethical issues related to genetic modification of organisms and that the nature of science can be described.

Finally, the NGSS learning outcomes place more emphasis on computational thinking and using and applying models than the DP does in its learning outcomes.

### 5.5.2 Content – Biology

This section compares and contrasts the content of DP biology and the NGSS falling within the category of biology. In order to support visual comparison at-a-glance, the DP content is presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 25: DP biology content visualiser*[86]

| | | | | |
|---|---|---|---|---|
| **A: Unity and diversity** | **1. Molecules** | A1.1 Water (SL + AHL) | A1.2 Nucleic acids (SL + AHL) | |
| | **2. Cells** | A2.1 Origins of cells (HL only) | A2.2 Cell structure (SL + AHL) | A2.3 Viruses (HL only) |
| | **3. Organisms** | A3.1 Diversity of organisms (SL + AHL) | A3.2 Classification and cladistics (HL only) | |
| | **4. Ecosystems** | A4.1 Evolution and speciation (SL + AHL) | A4.2 Conservation and biodiversity | |
| **B: Form and function** | **1. Molecules** | B1.1 Carbohydrates and lipids | B1.2 Proteins (SL + AHL) | |
| | **2. Cells** | B2.1 Membranes and membrane transport (SL + AHL) | B2.2 Organelles and compartmentalization (SL + AHL) | B2.3 Cell specialization (SL + AHL) |
| | **3. Organisms** | B3.1 Gas exchange (SL + AHL) | B3.2 Transport (SL + AHL) | B3.3 Muscle and mobility (HL only) |
| | **4. Ecosystems** | B4.1 Adaptation to environment | B4.2 Ecological niches | |
| **C: Interaction and independence** | **1. Molecules** | C1.1 Enzymes and metabolism (SL + AHL) | C1.2 Cell respiration (SL + AHL) | C1.3 Photosynthesis (SL + AHL) |
| | **2. Cells** | C2.1 Chemical signalling (HL only) | C2.2 Neural signalling (SL + AHL) | |
| | **3. Organisms** | C3.1 Integration of body systems (SL + AHL) | C3.2 Defence against disease | |
| | **4. Ecosystems** | C4.1 Populations and communities | C4.2 Transfers of energy and matter | |
| **D: Continuity and change** | **1. Molecules** | D1.1 DNA replication (SL + AHL) | D1.2 Protein synthesis (SL + AHL) | D1.3 Mutations and gene editing (SL + AHL) |
| | **2. Cells** | D2.1 Cell and nuclear division (SL + AHL) | D2.2 Gene expression (HL only) | D2.3 Water potential (SL + AHL) |
| | **3. Organisms** | D3.1 Reproduction (SL + AHL) | D3.2 Inheritance (SL + AHL) | D3.3 Homeostasis (SL + AHL) |
| | **4. Ecosystems** | D4.1 Natural selection (SL + AHL) | D4.2 Sustainability and change (SL + AHL) | D4.3 Climate change (SL + AHL) |
| **Experimental programme** | **Practical work** | Collaborative sciences project | Scientific investigation | |

[86] '(HL only)' and '(SL + AHL)' are used to flag, respectively, topics only taught at HL and topics taught at both SL and HL, but which also feature additional higher level content.

*Figure 26: NGSS LS (biology) content visualiser[87]*

| | | | | | |
|---|---|---|---|---|---|
| Core | **LS1: From Molecules to Organisms: Structures and Processes** | LS1.A: Structure and Function | LS1.B: Growth and Development of Organisms | LS1.C: Organization for Matter and Energy Flow in Organisms | LS1.D: Information Processing |
| | **LS2: Ecosystems: Interactions, Energy, and Dynamics** | LS2.A: Interdependent Relationships in Ecosystems | LS2.B: Cycles of Matter and Energy Transfer in Ecosystems | LS2.C: Ecosystem Dynamics, Functioning, and Resilience | LS2.D: Social Interactions and Group Behavior |
| | **LS3: Heredity: Inheritance and Variation of Traits** | LS3.A: Inheritance of Traits | LS3.B: Variation of Traits | | |
| | **LS4: Biological Evolution: Unity and Diversity** | LS4.A: Evidence of Common Ancestry and Diversity | LS4.B: Natural Selection | LS4.C: Adaptation | LS4.D: Biodiversity and Humans |
| Crosscutting concepts | **Patterns** | | | | |
| | **Cause and effect: Mechanism and explanation** | | | | |
| | **Scale, proportion, and quantity** | | | | |
| | **Systems and system models** | | | | |
| | **Energy and matter: Flows, cycles, and conservation** | | | | |
| | **Structure and function** | | | | |
| | **Stability and change** | | | | |
| Scientific and Engineering Practices | **Asking questions (for science) and defining problems (for engineering)** | | | | |
| | **Developing and using models** | | | | |
| | **Planning and carrying out investigations** | | | | |
| | **Analyzing and interpreting data** | | | | |
| | **Using mathematics and computational thinking** | | | | |
| | **Constructing explanations (for science) and designing solutions (for engineering)** | | | | |
| | **Engaging in argument from evidence** | | | | |
| | **Obtaining, evaluating, and communicating information** | | | | |

[87] NB: only biology-focused units of work from the life sciences standards have been included. Units pertaining to other scientific disciplines are included in the relevant subject's section.

*Structure*

As with the NGSS PS, the NGSS LS are taught in four years (grade 9-12) within five topics. The performance expectations outlined are blended with core ideas, cross cutting concepts and scientific and engineering practices. In comparison, DP biology is taught through four themes that are separated into four levels of organisation and guiding questions accompanied by content, application of skills and nature of science links.

In LS there is one pathway, with students studying all high school science topics outlined. In contrast, the DP provides two routes for learning; SL and HL, with the HL biology content being more conceptually demanding and explored in greater depth.

The DP biology course outlines specific tools to be covered in three areas – experimental, technology and mathematics. Whilst the NGSS do cover elements of each tool, it does not cover them to the same depth and detail; for example, the NGSS biology makes reference to applying general mathematics by using units, symbols and numerical values, and graphing, but does not include processing uncertainties, which is required in DP biology Tool 3: Mathematics. The DP stipulates that students should show awareness of the purpose and practice of 10 biology techniques, which are outlined in Tool 1: Experimental techniques. The NGSS standards make reference to only three of the 10 techniques required in the DP – physical and digital modelling; identifying and classifying organisms and using a variety of sampling techniques/using random; and systematic sampling.

Overall, despite some structural similarities, DP biology has a significantly more defined content structure than the NGSS, with student experiences of those studying the latter likely varying significantly.

*Content Alignment*

To complement the analysis on content alignment, the figure below represents a simplified summary of the NGSS's content alignment, at topic-level, with DP biology (SL and HL)

*Figure 27: Summary of the alignment between the DP biology topics and the NGSS LS standards*

| DP biology topics | Presence of SL content in the NGSS LS | Presence of AHL content in the NGSS LS |
|---|---|---|
| A1 Unity and diversity – Molecules | | |
| A2 Unity and diversity – Cells | | |
| A3 Unity and diversity – Organisms | | |
| A4 Unity and diversity – Ecosystems | | |
| B1 Form and function – Molecules | | |
| B2 Form and function – Cells | | |
| B3 Form and function – Organisms | | |
| B4 Form and function – Ecosystems | | N/A |
| C1 Interaction and independence – Molecules | | |
| C2 Interaction and independence – Cells | | |
| C3 Interaction and independence – Organisms | | |
| C4 Interaction and independence – Ecosystems | | N/A |
| D1 Continuity and change – Molecules | | |
| D2 Continuity and change – Cells | | |
| D3 Continuity and change – Organisms | | |
| D4 Continuity and change – Climate Change | | |
| Experimental programme | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *There is strong presence of this topic in the NGSS* | | *There is partial presence of this topic in the NGSS* | | *There is little or no presence of this topic in the NGSS* |

Across all NGSS, five of the sixteen units studied are focused on biology topics, which is likely to result in considerable amount of time being dedicated to the teaching of the subject across the four years of high school.

The NGSS partially cover approximately 80% of the DP biology SL sub-topics, including natural selection, transfers of energy and matter, populations and communities, water, and nucleic acids. However, although many of the sub-topics from DP biology SL are covered, they lack sufficient depth and detail to be comparable. For example, neural signalling is referenced in Structure and Function LS1-2, but the NGSS assessment boundary limits the depth to which it can be studied as it stipulates learning 'does not include interactions and functions at the molecular or chemical reaction level'. Moreover, various DP biology SL sub-topics are altogether absent from the NGSS, including: membranes and membrane transport, organelles and compartmentalisation, transport, enzymes and metabolism, defence against disease, water potential and reproduction.

Although there is considerable alignment of sub-topics between the DP biology SL and NGSS, despite the latter covering content in considerably lower detail and depth, most of the DP biology HL sub-topics are not covered. The few DP biology HL sub-topics that are covered include nucleic acids, the origin of cells, natural selection, DNA replication, protein synthesis, sustainability and change, and climate change. However, these topics are covered in less depth and detail than would be expected in the DP biology HL course.

*Table 20: NGSS content that is not covered by DP biology*

| **Significant NGSS content which is not included in DP biology*** |
|---|
| ○ There is no specific content within NGSS LS that is not covered by the DP biology course. |

* Significant content does not include topics that are typically studied *prior* to upper secondary

### 5.5.3 Demand – Biology

The DP and the NGSS curricula were analysed using the same demand tool in order to create a demand profile for DP biology SL, DP biology HL, and the NGSS Life Sciences standards. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles superimposed in one place, enabling immediate visual comparison.

*Figure 28: Visual representations of subject demand*


The panel of experts carried out a detailed analysis of each course and reached a consensus on the scores shown in the profiles above. The following points were particularly important within the panel discussion:

- Regarding the scores for **Bloom's Cognitive Skills:**
  - DP biology has the same learning outcomes for both SL and HL, meaning that these scores are the same. These were judged to merit a score of 3 due to the high levels of critical thinking, critical awareness and elements of synthesis and creation present in the majority of aims and assessment objective 3.
  - For the NGSS, a Bloom's score of 2 was deemed appropriate given a predominant focus of the K-12 Framework on knowledge acquisition and application, with some presence (though limited) of higher-order thinking skills, such as evaluation, and emphasis on cross-curricular links. It was noted by the panel that there are good

examples of individual states providing more detail on how to apply the standards effectively, though this detail is absent from the NGSS themselves.

- Regarding the scores for **Depth of Knowledge:**
    - DP biology SL was deemed to merit a score of 2 for Depth of Knowledge due to the pre-requisite skills and competences (e.g. interpretation of graphs data, mathematics skills, some chemistry and geography links) required to access the course, as well as the moderate to high level of cognitive complexity of the knowledge that students are expected to acquire. As to the HL course, the greater depth and additional opportunities provided for extended thinking in the additional higher level option topics pushed the score to a 3.
    - For the NGSS, the depth of knowledge was seen to meet a score of 1 due to the key pre-requisite requirements and some reference to application of knowledge to real-world context, though the lack of guidance on how knowledge and skills should be built throughout the years of study made it difficult to ascertain the depth of this knowledge application.

- Regarding the scores for **Volume of Work:**
    - DP biology SL was judged to comprise a moderate-heavy workload (a score of 2) as students are exposed to multiple biology topics, with each topic being allocated a standard to short amount of time. The volume demands of the HL course, on the other hand, were found to be sufficient to meet a score of 3 – even though the proportion of topics per allocated teaching hour is smaller, these topics are covered in great depth and with a focus on application.
    - In contrast, the NGSS received a score of 0 for volume of work due to the apparently light depth and detail of knowledge and skills evidenced in the documentation. However, it was noted that the real breadth and depth of content, as well as time allocation per theme, may vary significantly from state to state or even school to school, depending on how the standards are applied.

- Regarding the scores for **Outstanding Areas of Subject Demand:**
    - For the DP biology SL course (awarded a score of 2), the IA research project that students need to undertake, the linking questions outlined in the syllabus and the collaborative sciences project were deemed to constitute areas of stretch. In addition to the latter, the HL course features additional higher levels topics which were deemed to include additional areas of stretch, meriting a score of 3.
    - As to the NGSS, a score of 0 was awarded as no clear areas of outstanding demand were identified – it was noted that the emphasis on cross-curricular linkages could provide opportunities for potential stretch, but that it was not possible to clearly infer this from the NGSS documentation.

# 6. Key Findings

This section provides brief summaries of the alignments and main similarities and differences found between the DP and the CCSS and NGSS, both at programme level and subject level. As the CCSS and NGSS are standards and do not constitute a full programme of study, this is a significant difference in its own right.

## 6.1 Programme Level

The **key similarities and differences** identified were the following:

- **Philosophical underpinnings**: there is some overlap between the philosophical underpinnings of the DP and those of the CCSS and NGSS, particularly in the emphasis placed on developing students' higher order thinking skills. Notably, all of the key themes within the IB's learner profile, approaches to teaching and approaches to learning, and philosophy of international-mindedness are present to at least some extent in the NGSS, while only some of the six themes are present to some extent within the CCSS. Thus, the design principles of the CCSS appear to be less aligned with those of the DP than those of the NGSS. Nevertheless, as neither the CCSS nor the NGSS constitute a programme of study, the level of alignment is likely to vary in line with implementation on a state-by-state basis.

- **Entry requirements**: neither the DP nor the CCSS and NGSS stipulate formal entry requirements. The DP encourages students and teachers to consult subject guides around expected prior learning but does not provide fixed entry requirements. There are also no fixed entry requirements outlined in the CCSS and NGSS, though, as the standards cover grades 9-12, there is an expectation that students will have completed their education up to at least grade 9, while for the DP this will be up to grade 11.

- **Structure**: there are some structural similarities between the DP and the CCSS and NGSS. For example, both the DP and the CCSS and NGSS cover the broad subject areas of languages, mathematics, and science and all three organise their subjects in subject categories based on the critical content in each group.
    - The DP features six subject groups, namely studies in language and literature, language acquisition, individuals and societies, sciences, mathematics, and the arts.
    - The CCSS organise their subjects into two thematic categories: English Language Arts and Mathematics.
    - The NGSS are organised around four thematic groupings: Physical Sciences, Life Sciences, Earth and Space Sciences, and Engineering Design.

  However, as the DP constitutes a full curriculum, it includes many components that are not present within the CCSS and NGSS, including subjects which fall outside the remit of those standards. Those subjects are often part of the high school curriculum at state level, and each state is responsible for designing and implementing these subjects, but there is no uniform approach across states.

- **Student learning pathways**: regarding the degree of specialisation available to students, the DP has a clear pattern for all students whereby subject groups enable specific choices that match the student's interests while maintaining the overall breadth of a baccalaureate-style programme. The CCSS and NGSS, on the other hand, are not a full curriculum and thus provide no information on student learning pathways, which are decided at the state level.

- **Assessment methods**: although the CCSS and NGSS unite the states that have signed up to them around key expectations for the skills and knowledge students should acquire by the end of each grade, the means of assessment – modes, types, frequency – are independently defined by each state. The DP, on the other hand, provides detailed subject-specific information on assessment modes, types and frequency (see the DP overview for further detail).

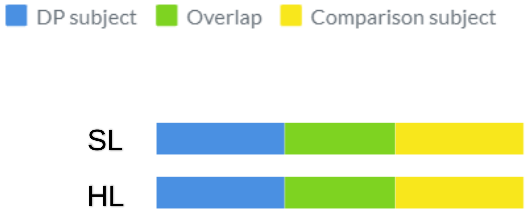
*Summary*

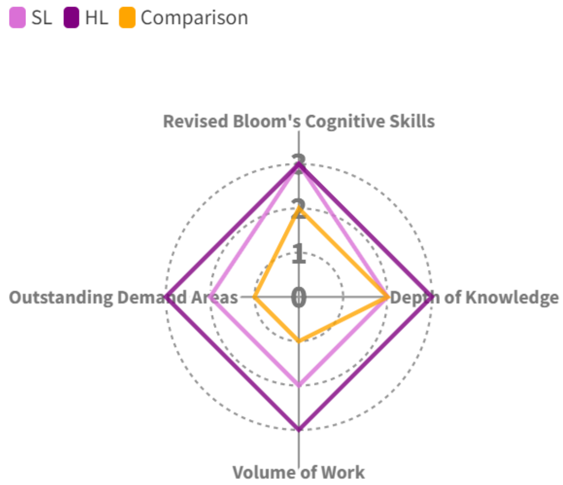
As the CCSS and NGSS are standards and not full programmes of study, they are implemented differently by each signatory state. While some similarities can be drawn between how the DP and the standards are implemented at programme-level, it is not possible to comment on programme-level alignment without commenting on how each CCSS and NGSS signatory state implements the standards in their own jurisdictions, a process which is beyond the scope of this project.

## 6.2 Subject Level

This section provides visual summaries of the subject-level alignment between specific subjects within the DP and the respective comparison points in the CCSS and NGSS. The summaries include key findings on learning outcomes alignment, content alignment and demand alignment, as per the key below:

*Key:*

<table>
<tr><th>Subject name</th><th>Learning outcomes alignment</th><th>Content alignment</th><th>Demand alignment</th></tr>
<tr>
<td>Displays the name of the comparison subject</td>
<td>Low<br>Moderate<br>High<br><br>This represents the learning outcome alignment between the DP subject and the comparison subject. A black border is placed around the selected judgement – ‘Moderate’ in this example.</td>
<td>

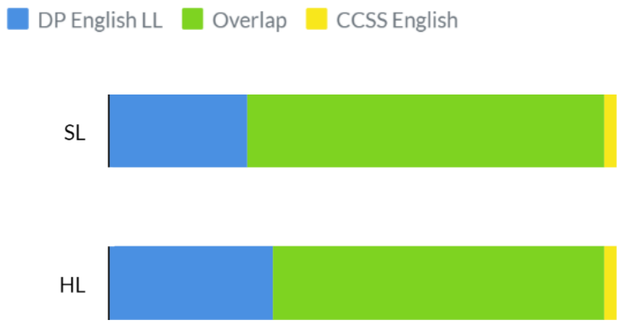
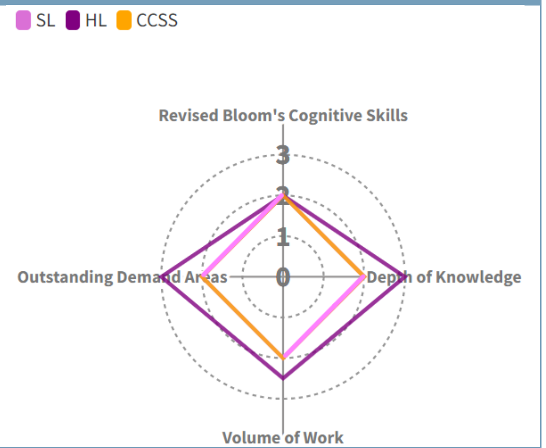
These bars represent the content alignment between the DP subject and the comparison. There is one bar showing alignment with SL content and another for HL content (inclusive of SL content). The green section of the bar represents the overlap of content between the subjects. The blue section represents content which was in the DP subject only. The yellow section represents content which was in the comparison subject only. Therefore, if, say, the blue section was longer than the yellow, this can be interpreted as the DP subject having more content unique to itself than the comparison did. A large green bar would indicate that a substantial proportion of content is common to both the DP and comparison subject.</td>
<td>

This radar diagram displays the demand judgement scores for the comparison subject(s) and the DP subject – both SL and HL.</td>
</tr>
</table>

### 6.2.1 English alignment

The subject-level alignment between the DP English LL and the CCSS is represented below:

*Figure 29: Visual representations of subject-level alignment (English subjects)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| CCSS English | Low<br>Moderate<br>**High** |  |  |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes in the DP English LL and the CCSS English is significant. Despite some differences in emphasis – for example, the CCSS require students to explicitly show technical competence and understanding of standard English in communication whereas the DP's requirements in this area are broader – all outcome themes extracted from the DP are present to at least some extent in the CCSS.

- **Content alignment**: the DP enables greater depth in content, particularly by encouraging metacognitive thinking. Regarding text choice, the DP is more prescriptive in what reading is allowed, whereas the CCSS have the potential to cover a larger range of texts. Generally, the DP includes most of the content described in the CCSS, as well as unique additional content.

- **Demand alignment**: the CCSS English are strongly aligned with the DP English LL SL course in demand, scoring the same for all categories. Meanwhile, the DP English LL HL scores higher for volume of work, depth of knowledge and number of stretch areas.

The **key similarities** identified were the following:

- **Similarities in learning outcomes:** all the six general learning outcome themes extracted from DP English LL are present to some extent in the CCSS. In terms of emphasis, both courses require students to develop their understanding of a diverse and varied range of texts and forms; both outline the requirement for understanding technical aspects of writers' crafts alongside how readers can extract meaning using analysis, interpretation, and evaluation; and both require students to formulate and express ideas for a range of purposes, tasks, and audiences.

- **Similarities in content:** there are a number of cases where DP English LL and the CCSS for English align in both subject breadth and depth. This is especially the case when students compare two different texts and explore points of similarity, and in understanding how a writer creates meaning using technical methods and word choices. Overall, a considerable number of the DP's areas of exploration were found to be fully or partially present in the CCSS English.

- **Similarities in demand**: in terms of demand, full alignment was deemed to exist between the DP English LL SL and the CCSS English.

The **key differences** identified were the following:

- **Differences in learning outcomes:** the DP English LL subject covers interdisciplinarity and intertextuality explicitly, whereas CCSS students may do incidentally but are not expected to understand these two concepts. Moreover, while DP English LL expects students to understand the relationship between a range of different contexts to different texts, students following the CCSS are not expected to explore an extensive variety of contexts or their explicit relationship to a text. On the other hand, the CCSS place much greater emphasis on technical accuracy and conventions of standard English than the DP. Whereas, in DP English LL, students are only required to communicate in a 'clear, logical and persuasive way', the CCSS anchor standards stipulate that students must demonstrate 'command' of 'standard English grammar', including 'capitalisation, punctuation and spelling when writing'. The CCSS also place more explicit emphasis upon students conducting independent research and carrying out projects.

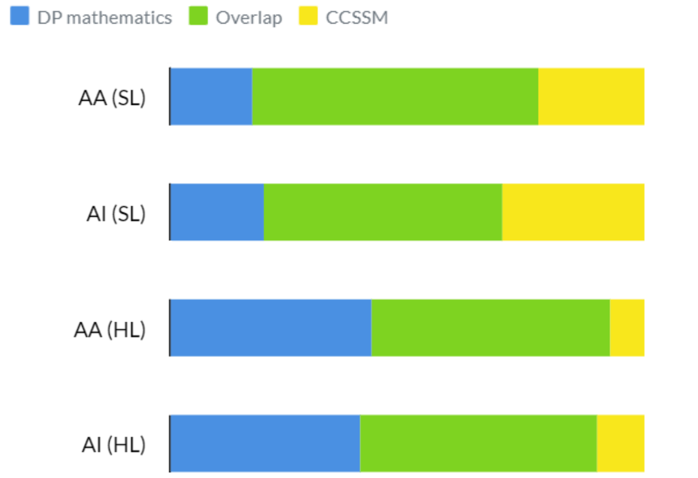
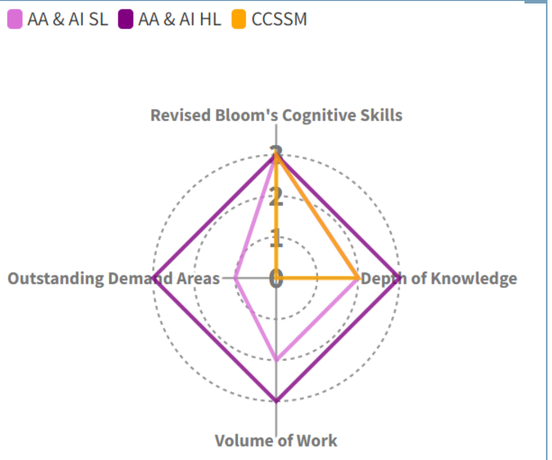
- **Differences in content:** there are considerable structural dissimilarities between the DP English LL and the CCSS English: the structure of DP English LL is broad and led by areas of exploration and smaller guiding questions, whereas the structure of the CCSS for English breaks down content into discrete standards, and tailors them to age groups. The literary text reading requirements for DP English LL are drawn from stricter criteria than the CCSS, where text choice is guided by principles. Conversely, students following the CCSS must select non-literary texts from a narrower pool than in the DP English LL. In terms of content alignment, the DP permits greater depth in content, particularly through the way it encourages students to think metacognitively about the subject. In some areas, the CCSS enable the development of skills which may allow considerable depth of thought, but such depth of conceptual complexity is not explicitly articulated in the standards. Regarding text choice, the DP is more prescriptive in what reading is allowed, whereas the CCSS potentially cover a larger range of texts – though practical levels of variation across different US schools are not fully revealed by the standards.

- **Differences in demand:** from a demand perspective, it is hard to gauge the real demand of the CCSS English in practice, as each state is free to independently decide how to implement them. Working purely from the documentation, the DP English LL SL and the CCSS English appear highly aligned in terms of demand, while the HL course is more demanding than the CCSS English. This is particularly due to the depth of knowledge, volume of work, and outstanding demand areas present in HL, which stretch students beyond both the CCSS English and the SL course of DP English LL.

### 6.2.2 Mathematics Alignment

The subject level alignment between the DP mathematics subjects and the CCSSM is represented below:

*Figure 30: Visual representations of subject-level alignment (mathematics subjects)*

<table>
<tr><th>Subject name</th><th>Learning outcomes alignment</th><th>Content alignment</th><th>Demand alignment</th></tr>
<tr><td>CCSSM</td><td>Low<br>Moderate<br>High</td><td>
</td><td>
</td></tr>
</table>

- **Learning outcomes alignment**: the level of alignment between both DP mathematics subjects, at both SL and HL, and the CCSSM learning outcomes is moderate. The DP and CCSSM share similar learning outcome themes involving critical thinking skills, use of technology, understanding and application, forming links and generalisations, communication skills, and learning skills. However, DP themes involving wider contexts and inquiry-based approaches are not evident in the CCSSM.

- **Content alignment**: the level of content alignment between DP mathematics subjects and the CCSSM is varied. The AA SL and CCSSM have the most content overlap, though the CCSSM do not share any calculus content, contain different geometry material and feature only a few AHL sub-topics. Moreover, the CCSSM do not contain enough AHL content to have significant overlap with HL overall. In summary, the CCSSM have slightly more depth in some topics than the DP SL subjects, but less breadth; and have both less breadth and depth than HL subjects.

- **Demand alignment**: all DP mathematics courses, both at SL and HL, considerably surpass the CCSSM in demand in terms of volume of work and stretch areas.

The key similarities identified were the following:

- **Similarities in learning outcomes**: like the DP, the CCSSM lay out general expectations which are applicable to all mathematics study. Six out of the eight themes extracted from the DP mathematics subject group are present in the CCSSM, hence there is considerable overlap between the DP and the CCSS in terms of learning outcomes. Overlapping themes – including problem-solving, reasoning, reflecting on and critiquing work, use of technology, and accuracy in the communication of mathematics – are generally emphasised and described in similar ways.

- **Similarities in content**: the content in the CCSSM is structured in a similar way to the DP, with the standards being organised into main topics involving functions, geometry, algebra, number, and statistics and probability. Furthermore, for all topics except calculus, much of the content in DP SL mathematics subjects is present in the CCSSM, especially for AA. With regards to HL content, there are strong similarities to the DP topic 'Number and algebra', due to the presence of complex numbers and matrices in the CCSSM. There is some limited similarity between the CCSSM and the HL content of 'Functions' (for both AA and AI) and 'Geometry and trigonometry' (AI only).

- **Similarities in demand**: both the DP and CCSSM score highly for the presence of higher order cognitive skills described in Bloom's Revised Taxonomy, by having a strong presence of evaluation and creation in their learning outcomes. Furthermore, the CCSSM score the same as the DP SL subjects for depth of knowledge, as content in many topics appears to be covered in considerable detail and depth.

The **key differences** identified were the following:

- **Differences in learning outcomes**: though the CCSSM learning outcomes have similarities with the DP mathematics subject group, the themes of inquiry-based approaches and wider contexts are not present. Furthermore, some of the detail in the DP's learning outcomes is missing – for example, learning skills such as working collaboratively and having curiosity are not features of the expectations, nor are making links to other disciplines. In addition, the CCSSM list two unique expectations involving searching for patterns in structure and looking for regularity in repeated reasoning. Both of these have similarities to the DP's theme of making links and generalisations, but both are more specific regarding the types of thinking students should engage in. The CCSSM also place more emphasis on modelling within their learning outcomes.

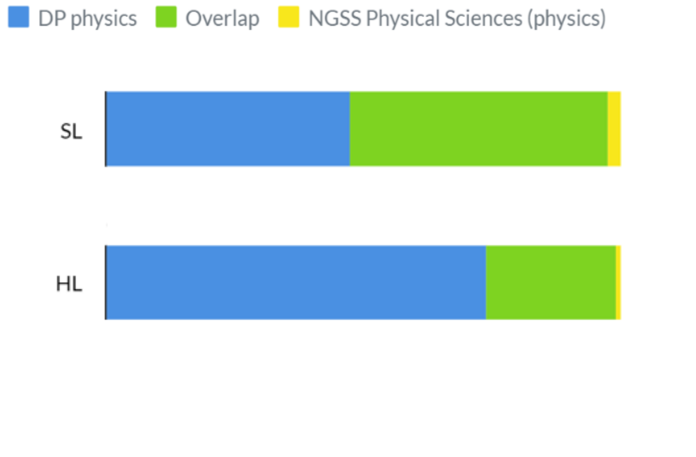
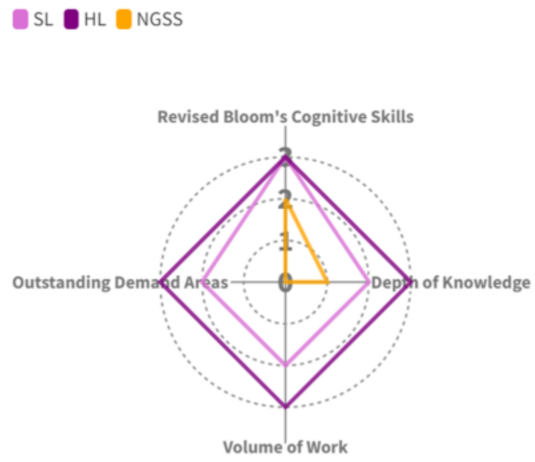
- **Differences in content:** a key difference is that the CCSSM content applies to four years of study, as opposed to two years in the DP. Moreover, unlike the DP, the CCSSM do not constitute a comprehensive curriculum and therefore do not describe all content in the same level of detail, especially for fourth course options. This leads to some strong differences in content. Most notably, the CCSSM do not detail content for the topic of calculus, which is one of the five main topics in DP mathematics subjects. Calculus (and pre-calculus) is usually the focus of fourth course study in the US. Furthermore, since the CCSSM content does not focus on more advanced mathematical study typically covered in fourth courses, DP HL content is largely not present in the CCSSM. Therefore, the CCSSM lack the breadth and depth of DP HL mathematics.

- **Differences in demand**: though scoring similarly to DP mathematics subjects for cognitive skills and depth of knowledge, there are significant differences in other demand categories. The most considerable difference between the DP and CCSSM is volume of work. Where DP subjects have moderate to heavy volume, the CCSSM appear to have a generous amount of time to cover content. However, as the CCSSM do not detail recommended teaching hours, the volume of work score is likely to vary from state-to-state implementation. The CCSSM also score lower for outstanding areas of demand, again because the standards do not comprehensively detail content studied in fourth courses. Overall, the demand level of the CCSSM is considerably lower than that of the DP HL subjects and somewhat lower than SL subjects.

### 6.2.3 Physics Alignment

The subject level alignment between the DP physics and the NGSS is represented below:

*Figure 31: Visual representations of subject-level alignment (physics subjects)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Physical Sciences (physics) | Low<br>Moderate<br>**High** |  |  |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of the DP physics course and those of the NGSS physical sciences is high, with most themes extracted from the DP learning outcomes being present in the NGSS's learning outcomes. Indeed, the NGSS also demonstrate a focus on scientific inquiry, critical thinking skills, and communication. However, there are slight differences with regards to the emphasis of certain themes, with the NGSS having a lesser focus on scientific implications and conceptual understanding and a greater focus on use of models and computational thinking.

- **Content alignment**: while there is some significant topic and sub-topic overlap between the NGSS and the DP physics SL, there is no alignment between the NGSS and DP AHL content, thus any overlap with the HL course pertains exclusively to the SL content common to both SL and HL. As to content depth and level of detail covered, these are considerably higher in both the DP physics SL and HL than in the NGSS, with both having a considerable amount of additional content not explicitly covered in the NGSS.

- **Demand alignment**: both the DP physics SL and HL considerably surpass the NGSS in demand level. The NGSS score lower in all categories, with particularly strong differences noted in outstanding areas of demand and volume of work. The NGSS do, however, score more closely to the DP when it comes to cognitive skills, as there is evidence of some higher-order thinking such as analysis.

The **key similarities** identified were the following:

- **Similarities in learning outcomes:** the majority of learning outcome themes extracted from DP physics is present to some extent in the NGSS, with similarities observed in the coverage of acquiring and applying knowledge, creative and critical thinking skills, investigation skills, use of technology, and effective communication and collaboration.

- **Similarities in content:** a good number of DP SL sub-topic areas are at least partially included in the NGSS topic coverage for physical sciences. In particular, the NGSS feature coverage of the DP SL sub-topics of forces and momentum, wave model, gravitational fields, and work, energy and power, though the mathematical requirements in the latter are not specified. In the sub-topic of kinematics, too, the NGSS feature scope to cover the same content as the DP, except for projectiles – not covered in the NGSS – and the mathematical requirements overall, which are also unclear. Moreover, both the NGSS and the DP have somewhat flexible structures, in that neither specifies a specific order for topics to be studied in, and both allow for practical demonstrations, modelling, and links to real world scenarios.

- **Similarities in demand**: both the DP and the NGSS show some evidence of higher-order thinking skills in their learning outcomes. However, while conceptual thought and critical thinking are predominant in the majority of the DP's course aims, reference to higher order thinking skills in the NGSS is limited.

The **key differences** identified were the following:

**Differences in learning outcomes:** there are some evident differences in the extent of the coverage of the DP learning outcome themes in comparison with the NGSS physical sciences. For example, development of conceptual understanding is not referenced in the NGSS, and consideration of ethical, social, environmental, and cultural implications of science is only present in a limited number of performance expectations. Conversely, a couple of outcome themes also receive greater emphasis in the NGSS when compared to the DP, namely the larger emphasis on the ability to use computational thinking and on understanding and applying scientific models.

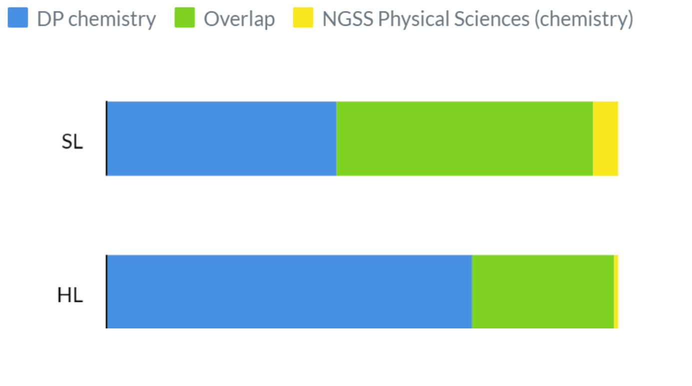
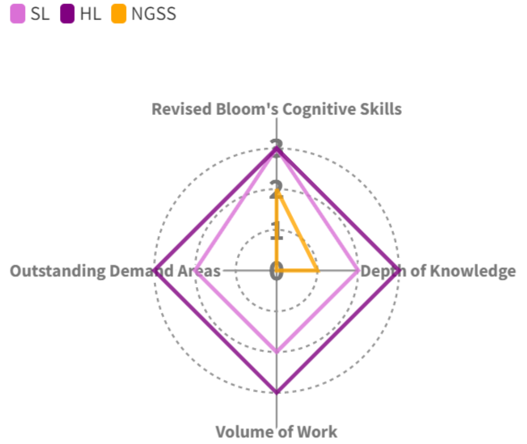
- **Differences in content:** none of the AHL content in the DP physics HL course is covered by the NGSS, with the only partial exception being gravitational fields. In relation to DP physics SL, although there is generally considerable topic overlap with the NGSS, a significant number of sub-topics are not covered in comparable depth, such as energy transfers; greenhouse effect; simple harmonic motion; wave phenomenon; electric and magnetic fields; structure of the atom; fission; fusion and stars; and radioactive decay. There are also clear structural differences between the DP and NGSS that stem from their overarching design principles – the DP highlights clear links to approaches to learning, the nature of science, and study skills in physics at topic level, while the NGSS are more focused on subject-specific objectives.

- **Differences in demand:** from a demand perspective, it is hard to gauge the real demand of the NGSS in practice, as each state is free to independently decide how to implement the standards. Working purely from the documentation, the NGSS are judged to be of much lower demand than both the DP physics SL and HL courses across all demand categories considered (Bloom's cognitive skills, depth of knowledge, volume of work, and outstanding demand areas).

### 6.2.4 Chemistry Alignment

The subject level alignment between the DP chemistry and the NGSS is represented below:

*Figure 32: Visual representations of subject-level alignment (chemistry subjects)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Physical Sciences (chemistry) | Low<br>Moderate<br>High |  |  |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of the DP chemistry course and those of the NGSS physical sciences is high, with most themes extracted from the DP learning outcomes being present in the NGSS's learning outcomes. Indeed, the NGSS also demonstrate a focus on scientific inquiry, critical thinking skills, and communication. However, there are slight differences with regards to the emphasis of certain themes, with the NGSS having a lesser focus on scientific implications and conceptual understanding and a greater focus on use of models and computational thinking.

- **Content alignment**: while there is some topic and sub-topic overlap between the NGSS and the DP chemistry SL, very limited alignment exists between the NGSS and the topics and sub-topics covered uniquely at HL. As to content depth and level of detail covered, this is considerably higher in both DP chemistry SL and HL than in the NGSS, with both having a considerable amount of additional content which is not present in the NGSS.

- **Demand alignment**: both the DP chemistry SL and HL considerably surpass the NGSS in demand level. The NGSS score lower in all categories, with particularly strong differences in outstanding areas of demand and volume of work. The NGSS do, however, score more closely with the DP on cognitive skills, as there is evidence of some higher-order thinking such as analysis.

The **key similarities** identified were the following:

- **Similarities in learning outcomes:** as with physics, the majority of general learning outcome themes extracted from DP chemistry is present to some extent in the NGSS, with similar coverage of acquisition and application of knowledge of ideas, theories and concepts in chemistry, creative and critical thinking skills, investigation skills, use of technology, and effective communication and collaboration.

- **Similarities in content:** the depth and breadth of content for chemistry in the DP, both at SL and HL, significantly exceed that of the chemistry topics in NGSS physical sciences. However, there is some coverage of key fundamental topic areas featured in the DP SL course, including periodicity, the mole concept, bonding, rates of reaction and the nuclear atom. Moreover, both the NGSS and the DP have somewhat flexible structures, in that neither specifies a specific order for topics to be studied in, and both allow for practical demonstrations, modelling, and links to real world scenarios.

- **Similarities in demand**: both the DP and the NGSS show some evidence of higher-order thinking skills in their learning outcomes. However, while conceptual thought and critical thinking are predominant in the majority of the DP's course aims, reference to higher order thinking skills in the NGSS is limited.

The **key differences** identified were the following:

- **Differences in learning outcomes:** there are some evident differences in the extent of the coverage of the DP themes in comparison with the NGSS physical sciences. Development of conceptual understanding is not referenced in the NGSS and consideration of ethical, social, environmental, and cultural implications of science is only present in a limited number of performance expectations. Additionally, a couple of outcome themes receive greater emphasis in the NGSS when compared to the DP, namely the larger emphasis on the ability to use computational thinking and on understanding and applying scientific models.

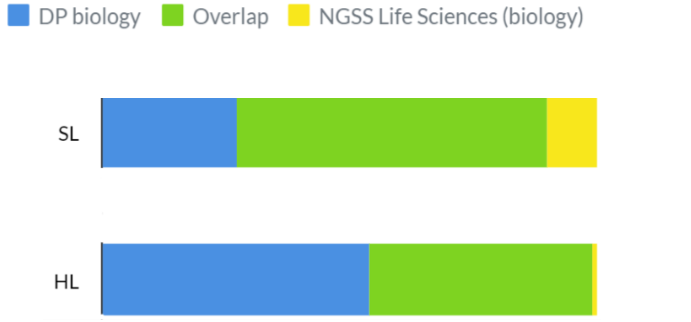
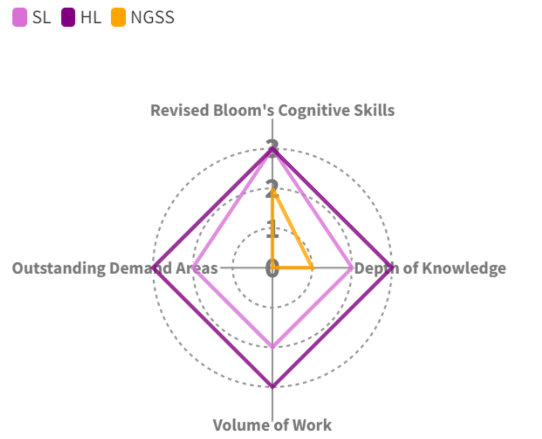
- **Differences in content:** the depth and breadth of content for chemistry in the DP, both at SL and HL, considerably exceed that of the chemistry topics in the NGSS physical sciences. The NGSS coverage of chemistry is significantly narrower and there is no reference to the majority of HL content in the NGSS content areas, while many SL sub-topics, such as electron configurations, ideal gases, classification of organic compounds, proton transfer, electron sharing, and transfer reactions, are also absent.
- **Differences in demand:** from a demand perspective, it is hard to gauge the real demand of the NGSS in practice, as each state is free to independently decide how to implement them. Working purely from the documentation, the NGSS have been judged

to be of much lower demand than both the DP chemistry SL and HL courses across all demand categories considered (Bloom's cognitive skills, depth of knowledge, volume of work and outstanding demand areas).

### 6.2.5 Biology Alignment

The subject level alignment between the DP biology and the NGSS is represented below:

*Figure 33: Visual representations of subject-level alignment (biology subjects)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| NGSS Life Sciences (biology) | Low<br>Moderate<br>**High** |  |  |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of the DP biology course and those of the NGSS life sciences is high, with most themes extracted from the DP learning outcomes being present in the NGSS's learning outcomes. Indeed, the NGSS also demonstrate a focus on scientific inquiry, critical thinking skills, and communication. However, there are slight differences with regards to the emphasis of certain themes, with the NGSS having a lesser focus on scientific implications and conceptual understanding and a greater focus on use of models and computational thinking.

- **Content alignment**: while there is considerable topic and sub-topic overlap between the NGSS and DP biology SL, there is limited alignment between the NGSS and the topics and sub-topics covered uniquely at HL. As to content depth and level of detail covered, this is considerably higher in DP SL and HL than in the NGSS.

- **Demand alignment**: both the DP biology SL and HL considerably surpass the NGSS in demand level. The NGSS score lower in all categories, especially for outstanding areas of demand and volume of work. The NGSS do, however, score more closely to the DP for cognitive skills, as there is evidence of some higher-order thinking such as analysis.

The **key similarities** identified were the following:

- **Similarities in learning outcomes:** as with physics and chemistry, the majority of learning outcome themes extracted from DP biology are present to some extent in the NGSS, with similar coverage of acquisition and application of knowledge of ideas, theories and concepts in biology, creative and critical thinking skills, investigation skills, use of technology, and effective communication and collaboration.

- **Similarities in content:** there is considerable alignment of sub-topics between the DP biology SL and NGSS, despite the latter covering content in considerably lower detail and depth. SL sub-topics covered by the NGSS include natural selection, transfers of energy and matter, populations and communities, water, and nucleic acids. Some DP biology HL sub-topics are also covered by the NGSS, though not in as much depth. These include: nucleic acid, the origin of cells, natural selection, DNA replication, protein synthesis, sustainability and change, and climate change. Moreover, both the NGSS and the DP have somewhat flexible structures, in that neither specifies a specific order for topics to be studied in, and both allow for practical demonstrations, modelling, and links to real world scenarios.

- **Similarities in demand**: both the DP and the NGSS show some evidence of higher-order thinking skills in their learning outcomes. However, while conceptual thought and critical thinking are predominant in the majority of the DP's course aims, reference to higher order thinking skills in the NGSS is limited.

The **key differences** identified were the following:

- **Differences in learning outcomes:** there are some evident differences in the extent of the coverage of the DP themes in comparison with the NGSS life sciences. Development of conceptual understanding is not referenced in the NGSS and consideration of ethical, social, environmental, and cultural implications of science is only present in a limited number of performance expectations. Additionally, a couple of outcome themes also emerged as receiving greater emphasis in the NGSS when compared to the DP, namely the larger focus on the ability to use computational thinking and on understanding and applying scientific models.

- **Differences in content:** generally speaking, the breadth of content in the NGSS life sciences is significantly lower than that of both the DP biology SL and HL. While there is substantial topic overlap between the NGSS and the DP biology SL, coverage often lacks sufficient depth and detail to be comparable. Moreover, various DP biology SL sub-topics are altogether absent from the NGSS, including: membranes and membrane transport, organelles and compartmentalisation, transport, enzymes and metabolism, defence against disease, water potential and reproduction. HL content is mostly absent from the NGSS, and, where present, is not covered in comparable depth.

- **Differences in demand:** from a demand perspective, it is hard to gauge the real demand of the NGSS in practice, as each state is free to independently decide how to implement them. Working purely from the NGSS documentation, the latter have been judged to be of much lower demand than both the DP biology SL and HL courses across all demand categories considered (Bloom's cognitive skills, depth of knowledge, volume of work and outstanding demand areas).

# 7. Bibliography

California Department of Education. (2022). *Curriculum & Instruction Subject Areas.* https://www.cde.ca.gov/ci/cr/cf/cimegasubjectareas.asp

District of Columbia. The Partnership for Assessment of Readiness for College and Careers (PARCC)*.* https://osse.dc.gov/parcc

International Baccalaureate. (2014). *International Baccalaureate Diploma Programme: A guide to assessment*.

International Baccalaureate. (2015). *Diploma Programme: From principles into practice*.

International Baccalaureate. (2015). *Language A: language and literature guide.*

International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*.

International Baccalaureate. (2017). *Assessment principles and practices: Quality assessments in a digital age*.

International Baccalaureate. (2017). *What is an IB Education?*

International Baccalaureate. (2019). *Mathematics: analysis and approaches guide*.

International Baccalaureate. (2019). *Mathematics: applications and interpretation guide.*

International Baccalaureate. (2021). *Assessment and Exams.* https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/

International Baccalaureate. (2021). *CAS projects.* https://www.ibo.org/programmes/diploma-programme/curriculum/creativity-activity-and-service/cas-projects/

International Baccalaureate. (2021). *Curriculum*. https://www.ibo.org/programmes/diploma-programme/curriculum/

International Baccalaureate. (2021). *Theory of knowledge*. https://www.ibo.org/programmes/diploma-programme/curriculum/theory-of-knowledge/

International Baccalaureate. (2021). *Understanding DP assessment.* https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/understanding-ib-assessment/

International Baccalaureate. (2022). *Diploma Programme*. https://www.ibo.org/programmes/diploma-programme/

International Baccalaureate. (2023). *Biology guide*.

International Baccalaureate. (2023). *Chemistry guide.*

International Baccalaureate. (2023). *Physics guide.*

Krathwohl, D. (2002). A Revision of *Bloom's taxonomy: An Overview.* Theory Into Practice, Vol 41(4). Available from: www.tandfonline.com/doi/abs/10.1207/s15430421tip4104_2?journalCode=htip20

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. About the Standards.* http://www.corestandards.org/about-the-standards/

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. *Standards for Mathematical Practice.* http://www.corestandards.org/Math/Practice/

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. English Language Arts Standards*. http://www.corestandards.org/ELA-Literacy/

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards. Frequently Asked Questions.* http://www.corestandards.org/wp-content/uploads/FAQs.pdf

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics.* Mathematics Standards | Common Core State Standards Initiative (corestandards.org)

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core Standards for Mathematics. Appendix A: Designing High School Mathematics Courses Based on the Common Core State Standards.* p. 8. Mathematics Appendix A_Teal1.indd (corestandards.org)

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. https://doi.org/10.17226/13165

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Topic arrangements of the NGSS.* https://www.nextgenscience.org/overview-topics

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Developing the Standards.* https://www.nextgenscience.org/developing-standards/developing-standards

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Factsheet.* https://www.nextgenscience.org/sites/default/files/resource/files/NGSSFactSheet2016revised.pdf

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Understanding the Standards.* Understanding the Standards | Next Generation Science Standards (nextgenscience.org)

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States. Appendix K. Model Course Mapping in Middle and High School for the Next Generation Science Standards*. https://www.nextgenscience.org/sites/default/files/Appendix%20K_Revised%208.30.13.pdf

Smarter Balanced Assessment Consortium (SBAC). https://smarterbalanced.org/

Webb, N. L. (2002). *Depth-of-knowledge levels for four content areas*. Language Arts. http://ossucurr.pbworks.com/w/file/fetch/49691156/Norm%20web%20dok%20by%20subject%20area.pdf

# Appendix A

This Appendix provides further detail on the criteria utilised by Ecctis' experts and external panel members with subject expertise to measure demand for each of the subjects analysed in this study.

*Demand Profile – Subject-level Judgement*

- **Revised Bloom's cognitive** skills score (0-3): this is an overall score of course demand, based entirely on a review of learning outcomes. Levels have been defined based on increasing emphasis on Bloom's Higher Order Thinking Skills.

    - Level 0 – remembering and understanding: learning outcomes (as well as assessment and content) are primarily focused on recall and understanding, with limited or no evidence of higher order thinking skills.
    - Level 1 – applying: learning outcomes (as well as assessment and content) comprise a mix of recall-, understanding- and application-focused objectives, with only limited presence of higher order thinking skills.
    - Level 2 – analysing: learning outcomes (as well as assessment and content) comprise a mix of recall-, understanding and application-focused goals but also feature a substantial focus on analysis. Learning outcomes can also potentially feature some (though limited) evidence of evaluation and creation-focused goals.
    - Level 3 – evaluating and creating (or synthesising): learning outcomes (as well as assessment and content) feature a predominant focus on analysis-, evaluation- and creation/synthesis.

- **Depth of knowledge** (adapted from Webb's) score (0-3): this is an overall score evaluating the depth of knowledge or complexity of knowledge required by curriculum standards and expectations. The score is focused on subject content and learning outcomes, complemented by assessment where relevant/possible. Levels have been defined based on the level of detail studied per topic, as well as the levels of thinking described in Webb's Depth of Knowledge framework.

    - Level 0 – All or most topics are studied in limited detail (pre-upper secondary level). Only basic pre-requisite knowledge is required in order to grasp ideas. The level of cognitive complexity of the information students are expected to know is low (e.g. many tasks may require recall and reproduction of information such as facts, definitions, terms, or simpler procedures – acquired knowledge).
    - Level 1 – Some topics are studied in considerable detail. Moderate levels of pre-requisite knowledge are required in order to grasp ideas in some topics. The level of cognitive complexity of the information students are expected to know is low to moderate (e.g. many tasks may require engagement of some mental processing beyond habitual responses, including comparison and basic reasoning – knowledge application).

- Level 2 – Most topics are studied in considerable detail. Considerable pre-requisite knowledge is required in order to grasp ideas in some topics. The level of cognitive complexity of the information students are expected to know is average to high (e.g. some tasks require complex reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands are often complex and abstract – analysis).
- Level 3 – All or most topics are studied in very high detail. Considerable pre-requisite knowledge is required in order to grasp ideas in most topics. The level of cognitive complexity of information students are expected to know is mostly high (e.g. many tasks may require complex reasoning, planning, developing, information synthesis, interpretation of data for problem solving, and thinking most likely over an extended period – extended thinking).

- **Volume of work** score (0-3): this is a trifactor score, considering breadth of content and depth of content, evaluated against the programme's specified timeframe. The three factors – breadth, depth, and time – were all considered in defining the levels.

  - Level 0 – light: small number of themes and sub-themes covered; a significant majority of time is spent on straightforward or basic themes; generous time allocation per theme.
  - Level 1 – moderate: typical number of themes and sub-themes covered; more time spent on conceptually complex themes compared to Level 1 (though majority of time still spent on themes of basic depth); standard time allocation per theme.
  - Level 2 – moderate heavy: typical to high number of themes and sub-themes covered; a significant proportion of time spent on issues beyond basic conceptual depth; standard to short time allocation per theme.
  - Level 3 – heavy: high number of themes and sub-themes covered; a large proportion of time spent on issues beyond basic conceptual depth; short time allocation per theme.

- **Outstanding areas of subject demand** score (0-3): this score reflects the number of content areas typically viewed as more challenging and/or conducive to intellectual stretching of learners. Levels have been defined on a scale of increasing presence of 'stretch areas'.

  - Level 0 – no stretch areas (0)
  - Level 1 – few stretch areas (1-2)
  - Level 2 – a significant number of stretch areas (3-4)
  - Level 3 – a high number of stretch areas (>4)

# Appendix B

| Learner profile | Approaches to learning | Approaches to teaching | International-mindedness |
|---|---|---|---|
| **Inquirers**: We nurture our curiosity, developing skills for inquiry and research. We know how to learn independently and with others. We learn with enthusiasm and sustain our love of learning throughout life.<br><br>**Knowledgeable**: We develop and use conceptual understanding, exploring knowledge across a range of disciplines. We engage with issues and ideas that have local and global significance.<br><br>**Thinkers**: We use critical and creative thinking skills to analyse and take responsible action on complex problems. We exercise initiative in making reasoned, ethical decisions.<br><br>**Communicators**: We express ourselves confidently and creatively in more than one language and in many ways. We collaborate effectively, listening carefully to the perspectives of other individuals and groups.<br><br>**Principled**: We act with integrity and honesty, with a strong sense of fairness and justice, and with respect for the dignity and rights of people everywhere. We take responsibility for our actions and their consequences.<br><br>**Open Minded**: We critically appreciate our own cultures and personal histories, as well as the values and traditions of others. We seek and evaluate a range of points of view, and we are willing to grow from the experience. | In all IB programmes, there are five categories of skills including:<br><br>**Thinking skills:** including areas such as critical thinking, creative thinking, and ethical thinking<br><br>**Research skills:** including skills such as comparing, contrasting, validating, and prioritizing information<br><br>**Communication skills:** including skills such as written and oral communication, effective listening, and formulating arguments<br><br>**Social skills:** including areas such as forming and maintaining positive relationships, listening | In all IB programmes, teaching is:<br><br>**Based on inquiry:** A strong emphasis is placed on students finding their own information and constructing their own understandings.<br><br>**Focused on conceptual understanding:** Concepts are explored in order to both deepen disciplinary understanding and to help students make connections and transfer learning to new contexts.<br><br>**Developed in local and global contexts:** Teaching uses real-life contexts and examples, and students are encouraged to process new information by connecting it to their own experiences and to the world around them.<br><br>**Focused on effective teamwork and collaboration:** This includes promoting teamwork and collaboration between students, but also refers to the collaborative relationship between teachers and students. | The aim of all IB programmes is to develop internationally minded people who recognize their common humanity and shared guardianship of the planet. Central to this aim is international-mindedness.<br><br>International-mindedness is a multifaceted concept that captures a way of thinking, being and acting characterised by an openness to the world and a recognition of our deep interconnectedness to others.<br>To be open to the world, we need to understand it. IB programmes therefore provide students with opportunities for sustained inquiry into a range of local and global issues and ideas. This willingness to see beyond immediate situations and boundaries is essential as globalization and emerging technologies continue to blur traditional distinctions between the local, national and international.<br><br>An IB education fosters international-mindedness by helping students reflect on their own perspective, culture and identities, as well as those of others. By engaging with diverse beliefs, values and experiences, and by learning to think and collaborate across cultures and disciplines, IB learners gain the understanding necessary to make progress towards a more peaceful world. |

| | | | |
|---|---|---|---|
| **Caring**: We show empathy, compassion, and respect. We have a commitment to service, and we act to make a positive difference in the lives of others and in the world around us.<br><br>**Risk-Takers**: We approach uncertainty with forethought and determination; we work independently and cooperatively to explore new ideas and innovative strategies. We are resourceful and resilient in the face of challenges and change.<br><br>**Balanced**: We understand the importance of balancing different aspects of our lives – intellectual, physical, and emotional – to achieve well-being for ourselves and others. We recognize our interdependence with other people and with the world in which we live.<br><br>**Reflective**: We thoughtfully consider the world and our own ideas and experience. We work to understand our strengths and weaknesses in order to support our learning and personal development. | skills, and conflict resolution<br><br>**Self-management skills:** including both organizational skills, such as managing time and tasks, and affective skills, such as managing state of mind and motivation. | **Designed to remove barriers to learning:** Teaching is inclusive and values diversity. It affirms students' identities and aims to create learning opportunities that enable every student to develop and pursue appropriate personal goals.<br><br>**Informed by assessment:** Assessment plays a crucial role in supporting, as well as measuring, learning. This approach also recognizes the crucial role of providing students with effective feedback. | An IB education further enhances the development of international-mindedness through multilingualism. All IB programmes require students to study, or study in, more than one language. This is because we believe that communicating in more than one language helps students to appreciate that his or her own language, culture and world view are just one of many. In this way, it provides excellent opportunities to develop intercultural understanding and respect.<br><br>International-mindedness is also encouraged through a focus on global engagement and meaningful service with the community. These elements challenge students to critically consider power and privilege, and to recognize that they hold this planet and its resources in trust for future generations. They also highlight the focus on action in all IB programmes: a focus on moving beyond awareness and understanding to engagement, action and bringing about meaningful change to make a more peaceful and sustainable world for everyone. |

# Appendix C

## CONFIDENTIAL

### Task brief – Expert Demand Panel – [Subject]

For each subject, highlight in yellow the descriptor(s) deemed to best fit each demand category, using the following criteria (please refer to the demand tables for descriptors of the levels):

- **Revised Bloom's cognitive skills** score (0-3): this is an overall score of course demand, based entirely on a review of learning outcomes. Levels have been defined based on increasing emphasis on Bloom's Higher Order Thinking Skills.

- **Depth of knowledge** (adapted from Webb's) score (0-3): this is an overall score evaluating the depth of knowledge or complexity of knowledge required by curriculum standards and expectations. The score is focused on subject content and learning outcomes, complemented by assessment where relevant/possible. Levels have been defined based on the level of detail studied per topic, as well as the levels of thinking described in Webb's Depth of Knowledge framework.

- **Volume of work** score (0-3): this is a trifactor score, considering breadth of content and depth of content, evaluated against the programme's specified timeframe. The three factors – breadth, depth and time – were all taken into account in defining the levels.

- **Outstanding areas of subject demand** score (0-3): this score reflects the number of content areas typically viewed as more challenging and/or conducive to intellectual stretching of learners. Levels have been defined on a scale of increasing presence of 'stretch areas'.

# Demand Judgements – [Subject]

*Table 21: [Subject]*

| Demand Judgement | Score Descriptors (highlight the best-fit descriptor) | Judgement and Key Evidence |
|---|---|---|
| Revised Bloom's Cognitive Skills[88] | Level 0 – remembering and understanding: learning outcomes are primarily focused on recall and understanding, with limited or no evidence of higher order thinking skills. | |
| | Level 1 – applying: learning outcomes (as well as assessment and content) comprise a mix of recall-, understanding- and application-focused objectives, with only limited presence of higher order thinking skills. | |
| | Level 2 – analysing: learning outcomes (as well as assessment and content) comprise a mix of recall-, understanding and application-focused goals but also feature a substantial focus on analysis. Learning outcomes can also potentially feature some (though limited) evidence of evaluation and creation-focused goals. | |
| | Level 3 – evaluating and creating (or synthesising): learning outcomes feature a predominant focus on analysis-, evaluation- and creation/synthesis. | |
| Depth of Knowledge[89] | Level 0 – All or most topics are studied in limited detail (pre-upper secondary level). Only basic pre-requisite knowledge is required in order to grasp ideas. The level of cognitive complexity of the information students are expected to know is low (e.g. many tasks may require recall and reproduction of information such as facts, definitions, terms, or simpler procedures – acquired knowledge). | |
| | Level 1 – Some topics are studied in considerable detail. Moderate levels of pre-requisite knowledge are required in order to grasp ideas in some topics. The level of cognitive complexity of the information students are expected to know is low to moderate (e.g. many tasks may require engagement of some mental processing beyond habitual responses, including comparison and basic reasoning – knowledge application). | |
| | Level 2 – Most topics are studied in considerable detail. Considerable pre-requisite knowledge is required in order to grasp ideas in some topics. The level of cognitive complexity of the information students are expected to know is average to high (e.g. some tasks require complex reasoning, planning, using evidence, and a higher level of thinking than the previous two | |

[88] Evidence pool: Learning outcomes
[89] Evidence pool: Learning outcomes, subject content, assessment types

| Demand Judgement | Score Descriptors (highlight the best-fit descriptor) | Judgement and Key Evidence |
|---|---|---|
| | levels. The cognitive demands are often complex and abstract – analysis). | |
| | Level 3 – All or most topics are studied in very high detail. Considerable pre-requisite knowledge is required in order to grasp ideas in most topics. The level of cognitive complexity of information students are expected to know is mostly high (e.g. many tasks may require complex reasoning, planning, developing, information synthesis, interpretation of data for problem solving, and thinking most likely over an extended period of time – extended thinking). | |
| Volume of work[90] | Level 0 – light: small number of themes and sub-themes covered; a significant majority of time is spent on straightforward or basic themes; generous time allocation per theme. | |
| | Level 1 – moderate: typical number of themes and sub-themes covered; more time spent on conceptually complex themes compared to Level 1 (though majority of time still spent on themes of basic depth); standard time allocation per theme. | |
| | Level 2 – moderate heavy: typical to high number of themes and sub-themes covered; a significant proportion of time spent on issues beyond basic conceptual depth; standard to short time allocation per theme. | |
| | Level 3 – heavy: high number of themes and sub-themes covered; a large proportion of time spent on issues beyond basic conceptual depth; short time allocation per theme. | |
| Outstanding areas of subject demand[91] | Level 0 – no stretch areas (0) | |
| | Level 1 – few stretch areas (1-2) | |
| | Level 2 – a significant number of stretch areas (3-4) | |
| | Level 3 – a high number of stretch areas (>4) | |

[90] Evidence pool: Subject content; assessment types and number; course duration; time allocated per topic/sub-topic (where available).
[91] Evidence pool: Subject content.