# DP Country Alignment Studies: Alignment of the Diploma Programme with the Ontario Secondary School Diploma (OSSD)

**Submitted by Ecctis to the IB**

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Ecctis

## Acronyms

| | |
|---|---|
| **AA** | mathematics: analysis and approaches |
| **AF** | Advanced Functions |
| **AHL** | additional higher level |
| **AI** | mathematics: applications and interpretation |
| **ATL** | approaches to teaching and learning |
| **CP** | Career-related Programme |
| **CAS** | creativity, activity, service |
| **CV** | Calculus and Vectors |
| **DM** | Mathematics of Data Management |
| **DP** | Diploma Programme |
| **HL** | higher level |
| **IB** | International Baccalaureate |
| **IBO** | International Baccalaureate Organisation |
| **IEP** | Individual Education Plan |
| **LO** | Learning Outcome |
| **MCQ** | Multiple Choice Question |
| **MYP** | Middle Years Programme |
| **OSSC** | Ontario Secondary School Certificate |
| **OSSD** | Ontario Secondary School Diploma |
| **OSSLT** | Ontario Secondary School Literacy Test |
| **PYP** | Primary Years Programme |
| **RfP** | Request for Proposal |
| **RQ** | Research Question |
| **SEL** | Social and Emotional Learning |
| **SHSM** | Specialist High Skills Major |

| | |
|---|---|
| **SL** | standard level |
| **TOK** | theory of knowledge |
| **UP** | University Preparation |
| **USA** | United States of America |
| **WIAIBE** | What is an IB education? |

# 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 USA (United States of America), 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 programme of education in Ontario, Canada. The comparison qualification in question is the Ontario Secondary School Diploma (OSSD).

## 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 does the DP curriculum align with the Ontario upper secondary curriculum? In what way are the curricula similar and in what way are they different in demand and difficulty? To what degree are the curricula compatible?

**RQ2:** To what degree do the curricula align with regards to their:

2.1: Philosophical underpinnings
- Objectives
- Principles
- Values.

2.2: Structure
- Learning areas
- Subject offerings
- Degree of specialization
- Time allocation.

2.3: Requirements
- Programme entry requirements
- Time requirements (i.e. programme duration, teaching hours, study hours)
- Certificate requirements (i.e. credits, passing and failing conditions, compensation options).

2.4: Assessment

- Nature of assessment (i.e. number, type, duration, question types, availability of marks)
- Assessment model (i.e. relative weighting of assessments to overall grades).

2.5: Student learning pathways
- Degree of specialization
- Options in subject (area) choice (i.e. compulsory subjects, electives).

**RQ3:** To what degree do the subjects align with regards to:
3.1: Content
- Topics (i.e. scope of content area, breadth, depth)
- Learning activities (i.e. difficulty, demand).

3.2: Expected learning outcomes
- Knowledge
- Competencies (i.e. subject-specific, 21st century competencies).

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 OSSD, 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 the DP and the OSSD subjects, 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

The structures of the two programmes are the most significant point of difference and the philosophical underpinnings are the most significant point of similarity. In all other respects, there are some notable differences, though with points of clear alignment with regards to how students would be likely to experience the programmes in practice. Key similarities and differences include:

- **Philosophical underpinnings**: significant overlap was found between the OSSD's and DP's philosophical underpinnings, with both being community-oriented and guided by principles of inclusion and diversity; both promoting linkages to real-world contexts; and both prioritising the development of conceptual thought, higher-order thinking, independence, and communication skills in students. Notably, the OSSD also promotes the development of students' identities in the specific context of Canada's various and diverse communities, while the DP has a global focus by nature.

[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).

- **Programme structure**: both programmes take a baccalaureate-style approach to encouraging breadth of study; target completion of an overarching diploma while also providing subject-specific grades; and include curricula components that sit alongside subjects (such as community activities). However, there are significant structural dissimilarities between both programmes. While the OSSD is four years in duration, the DP is only two. Moreover, the OSSD's 30-credit structure leads to a larger number of subjects being experienced by students, whereas the DP's six-subject structure leads to a smaller number of subjects.

- **Entry requirements**: both the DP and the OSSD present a flexible approach to entry requirements at the start of their programmes, with neither having fixed entry requirements. However, while there are no entry requirements for OSSD subjects at grades 9, students' choices of what to study in subsequent years are shaped by what they have successfully completed in each year. In contrast, the DP does not have subject-specific entry requirements – it simply advises students to consult subject guides for prior learning expectations – but it does typically fix students into their subject choices for the full duration of the programme.

- **Student learning pathways**: both programmes provide a significant level of optionality in relation to subjects studied and both provide general guidance on what students can choose by directing them towards a balance of different subject groupings. The approach to combining subject-specialisation with breadth is therefore fairly similar; however, the structural dissimilarities mean that the practical nature of student pathways are inevitably quite different. The same student looking at both programmes would have to make fairly different practical choices to achieve the specific subject balances required by each diploma, though both would enable that student to pursue subjects that interest them to a higher level than subjects that are less significant to their intended pathway.

- **Assessment methods**: whereas the DP uses external terminal assessment to make up most of its assessment in each individual subject, the OSSD uses flexible internal assessment to comprise the full weighting of assessment in all subjects. However, the flexibility of the OSSD's internal assessment could result in a practical student experience that is similar to the DP's assessment patterns. Both programmes do use terminal assessment at the end of a period of study, along with coursework-style tasks in the duration of each course. Moreover, the types of assessment, questions and skills assessed in each programme and the weighting assigned to these also appear to be broadly aligned.

**Subject-level**

In this study, Ecctis carried out subject-level comparative analysis between the DP and the OSSD in mathematics, physics, chemistry and biology, focusing on the following DP and comparison subjects:

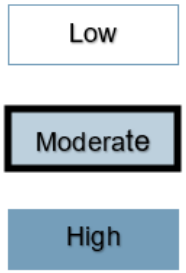
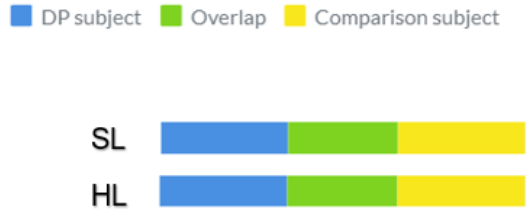
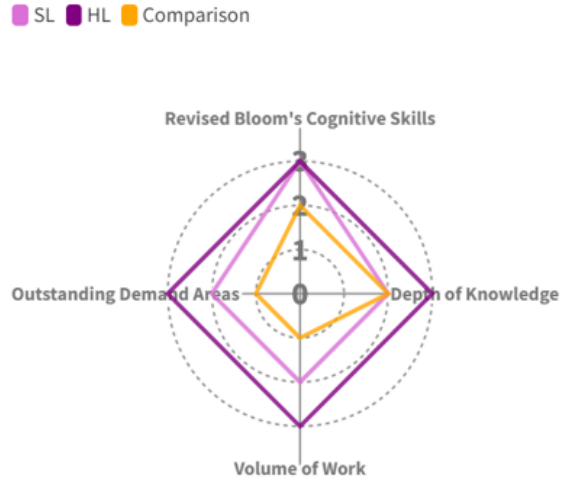
*Table: Subject areas for comparison of the DP and the OSSD curricula*

| **DP subject (group)** | **Ontario (Canada) subjects** |
|---|---|
| *SCIENCES* | |
| biology SL & HL | biology |
| chemistry SL & HL | chemistry |
| physics SL & HL | physics |
| *MATHEMATICS* | |
| mathematics: analysis and approaches (AA) SL & HL | Grade 9 De-streamed<br>Grade 10 Foundations of Mathematics<br>Grade 10 Principles of Mathematics<br>Grade 11 Functions, University Preparation<br>Grade 11 Functions and Applications, University/College Preparation<br>Grade 12 Advanced Functions, University Preparation<br>Grade 12 Calculus and Vectors, University Preparation<br>Grade 12 Mathematics of Data Management, University Preparation |
| mathematics: applications and interpretation (AI) SL & HL | |

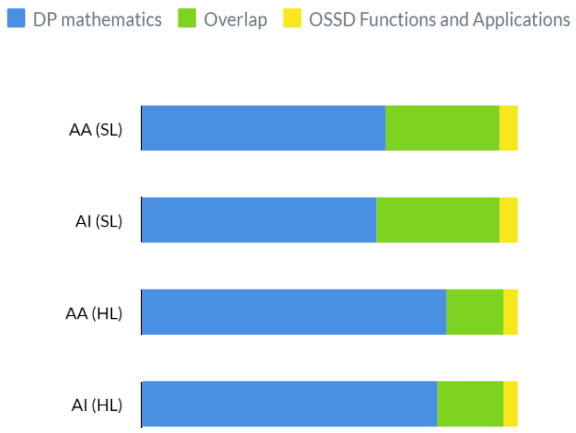
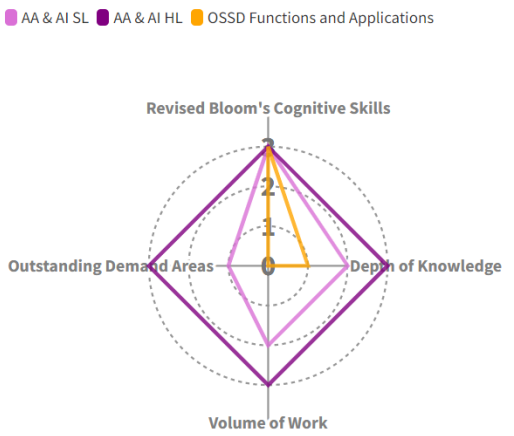
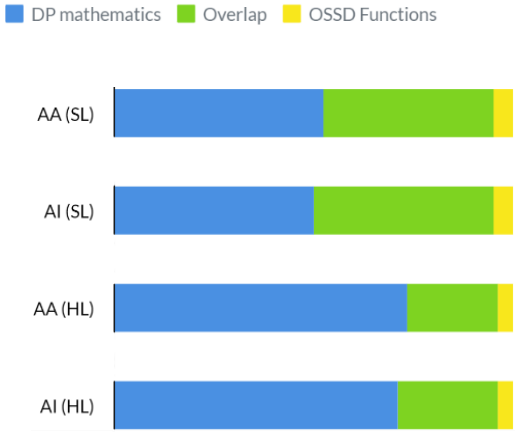
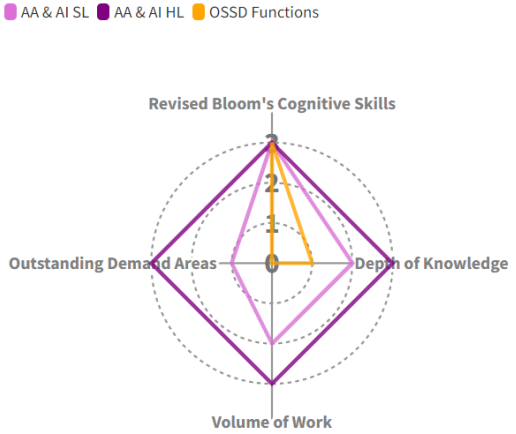
The findings from the subject-level analysis are summarised in the tables below:

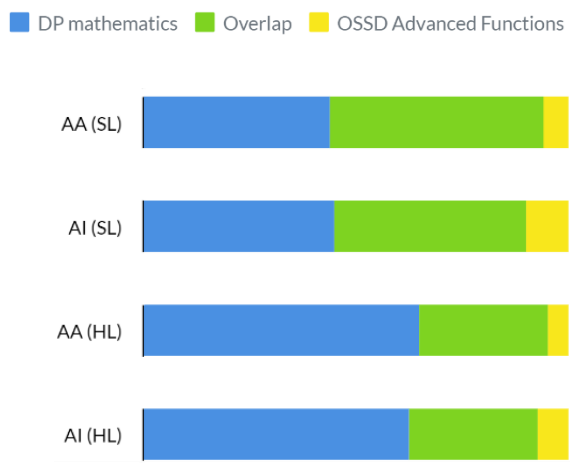
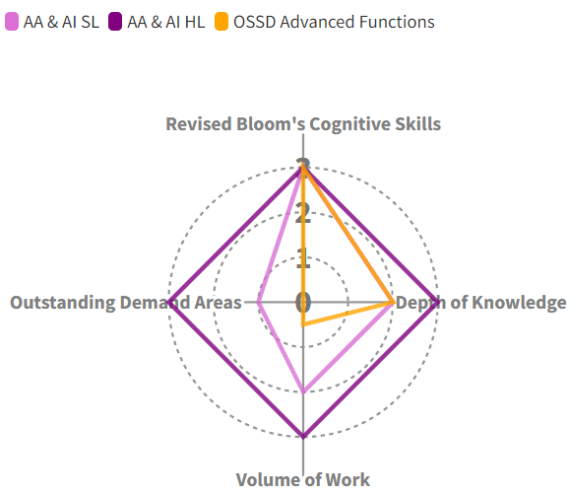
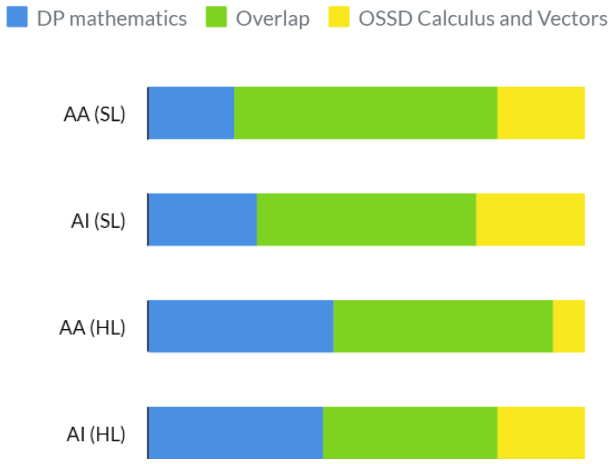
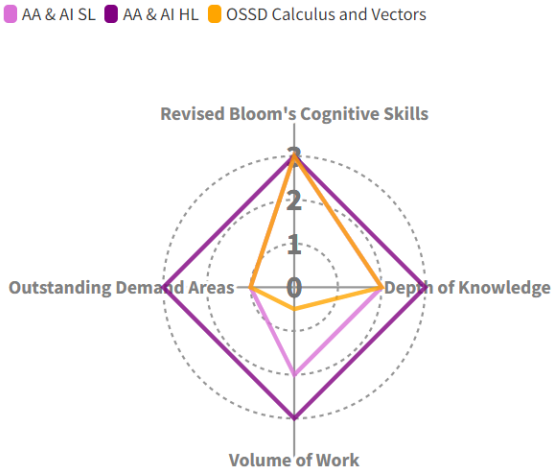
*Figures: Visual representation of alignment between DP subjects and comparison subjects*[2]

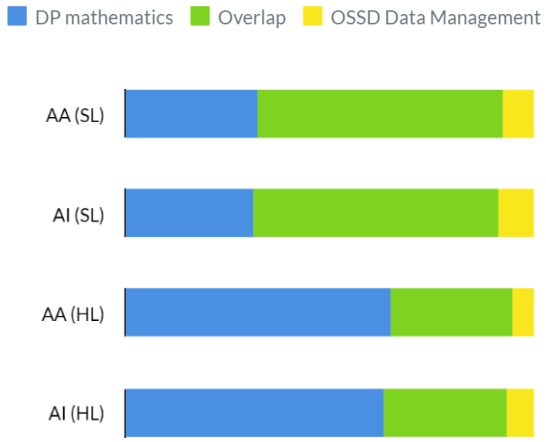
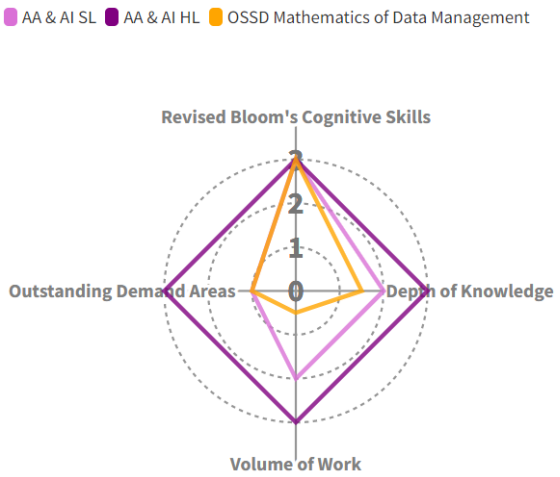
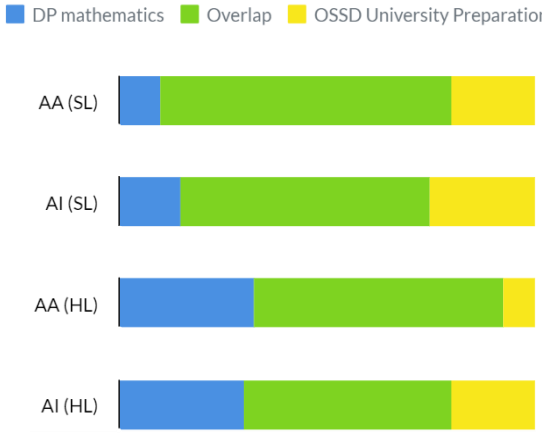
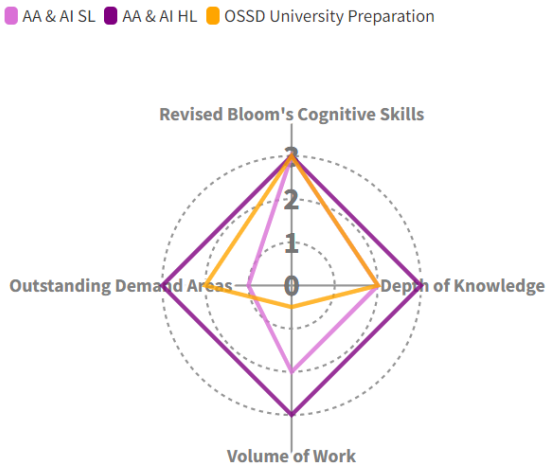
*Key:*

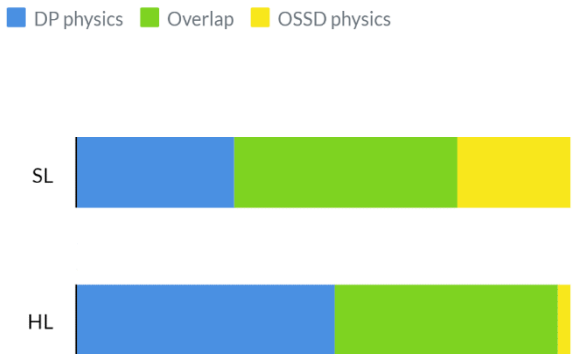
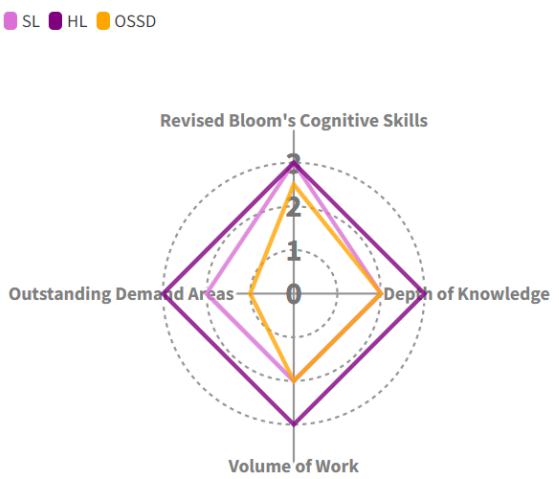
| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Displays the name of the comparison subject |  This represents the learning outcome alignment between the DP subject and the comparison subject. A black border is placed around the selected judgement – 'Moderate' in this example. |  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. |  This radar diagram displays the demand judgement scores for the comparison subject(s) and the DP subject – both SL and HL. |

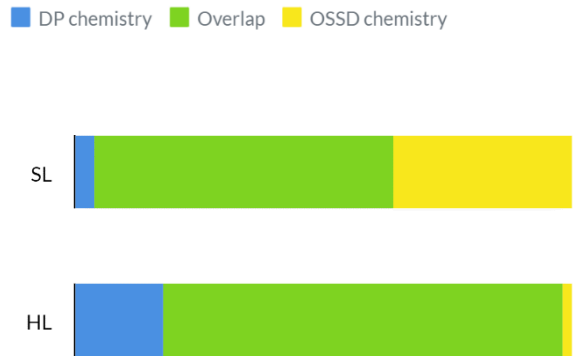
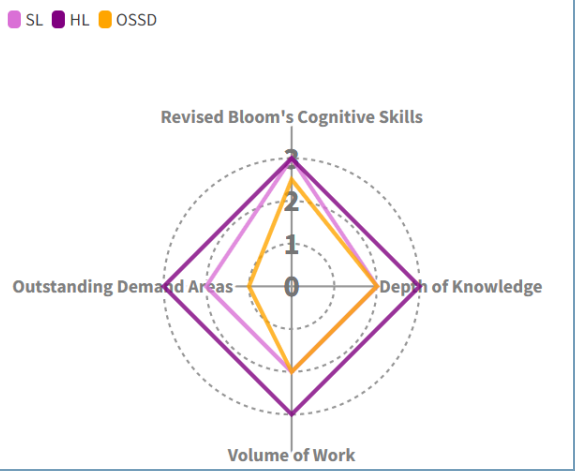
[2] For purposes of relevance and simplicity, only grade 11 and grade 12 subjects have been included in the table.

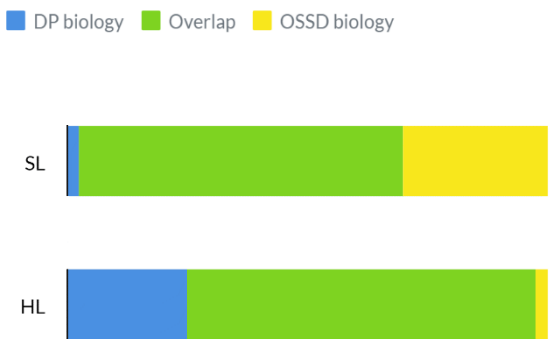
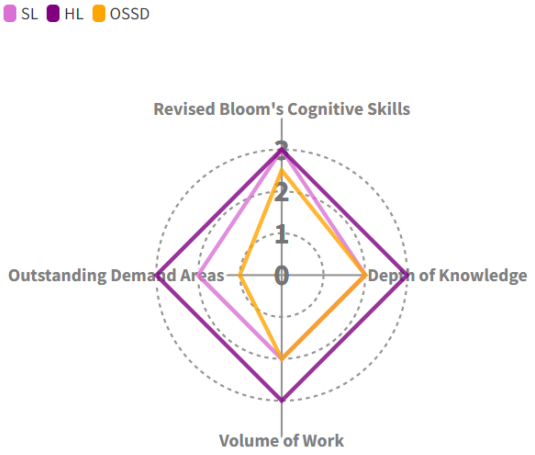
| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 11 Functions and Applications (F & A) | Low<br>Moderate<br>**High** |  |  |
| Grade 11 Functions | Low<br>Moderate<br>**High** |  |  |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 12 Advanced Functions (AF) | Low<br>Moderate<br>**High** |  |  |
| Grade 12 Calculus and Vectors (CV) | Low<br>Moderate<br>**High** |  |  |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 12 Mathematics of Data Management (DM) | Low<br>Moderate<br>**High** |  |  |
| University Preparation (UP) | Low<br>Moderate<br>**High** |  |  |

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

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

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| 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. Key highlights are summarised below. Notably, the analysis and judgements mostly focused on grades 11 and 12, as courses in these grades are more meaningfully comparable to the DP. Grades 9 and 10 were considered when reviewing learning outcomes and the structure of content, but not demand.

*Mathematics*

- **Learning outcomes alignment**: the level of alignment between both DP mathematics subjects, at both SL and HL, and the OSSD courses' learning outcomes is high, with all themes extracted from the DP's learning outcomes being present in all OSSD mathematics subjects' learning outcomes.

- **Content alignment**: the level of content alignment between DP mathematics subjects and individual OSSD courses varies. For grade 11, alignment is generally low, as courses focus primarily on functions rather than a breadth of topics—it is not until grade 12, when further mathematical areas are offered for study, that more substantial alignment can be observed. Generally, there is considerable content overlap with SL mathematics subjects, but limited overlap with HL subjects, except for where 'Calculus and Vectors' is studied or where all University Preparation mathematics courses are studied together. Typically, and especially at HL, the DP contains more content than the OSSD comparison points.

- **Demand alignment**: DP mathematics courses, both at SL and HL, usually surpass the OSSD courses in demand level. However, both 'Calculus and Vectors' and 'Data Management' score very similarly to DP SL for cognitive skills, depth of knowledge, and outstanding demand areas. When all OSSD University Preparation mathematics courses are combined, they score similarly to DP SL for cognitive skills and depth of knowledge but score higher for outstanding areas of demand. For all OSSD courses, the main differences are with regards to volume of work, with the DP scoring significantly higher in this category.

*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 DP and OSSD science subjects is significant, with all themes extracted from the DP learning outcomes being present in the OSSD's learning outcomes. While there are some small differences in focus – for example, the OSSD emphasising knowledge of Canadian contributions to science and making less explicit reference to scientific communication than the DP – the level of overlap is, nevertheless, substantial.

- **Content alignment**: there is reasonable topic and sub-topic overlap between the DP and the OSSD science subjects, for both SL and HL, with stronger alignment observed in chemistry and biology than in physics. OSSD chemistry and biology contain most SL topics and a considerable number of HL topics. Hence, their contents exceed that of DP SL and have reasonable overlap with HL. OSSD physics has less overlap with SL and instead has a mixture of SL and additional higher level (AHL) topics, thus it has more depth than SL in certain areas. All DP HL science subjects cover more content and go into more detail than OSSD subjects, though this is more significant for physics than chemistry and biology.

- **Demand alignment**: the demand level of the OSSD science subjects is judged to be moderately to highly aligned with that of the DP SL science subjects, although the OSSD subjects feature fewer stretch areas than the SL subjects. The DP HL significantly surpasses OSSD in demand level, featuring more stretch areas, greater depth of knowledge, and a higher volume of work.

### Summary

The programme-level features of the DP and OSSD are moderately aligned. The two programmes observe similar philosophical underpinnings and share similarities in their entry requirements and assessment objectives, though they differ in assessment methods, programme structure and student learning pathways. At subject-level, alignment between the OSSD and DP varies across subjects, being strongest when judging the DP against grade 12 subjects in the OSSD (as opposed to 9, 10 and 11 grade subjects). For mathematics, alignment levels are highest when comparing the DP against all the OSSD University Preparation mathematics courses taken as a whole, though substantial overlap can also be found with the grade 12 ‘Calculus and Vectors’ subject. As for science, there was varying alignment, with OSSD physics judged to be moderately aligned with DP physics, and both OSSD chemistry and biology considered to be moderately to highly aligned with DP chemistry and DP biology, respectively.

# 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), 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'.[3]

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.[4] More specifically, the studies aim to identify areas of similarities and differences between the DP and these educational systems by comparing philosophical underpinnings, 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 graduates.

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 Canadian upper-secondary programme of education. As agreed with the IB, since Canada organises its education at the provincial level, this report focuses specifically on the Ontario upper-secondary programme of education.

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

## 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:

### Ontario (Canada) Research Questions

*Table 1: Ontario (Canada) research questions*

**RQ1:** To what degree does the DP curriculum align with the Ontario upper secondary curriculum? In what way are the curricula similar and in what way are they different in demand and difficulty? To what degree are the curricula compatible?

**RQ2:** To what degree do the curricula align with regards to their:

2.1: Philosophical underpinnings
- Objectives
- Principles
- Values.

2.2: Structure
- Learning areas
- Subject offerings
- Degree of specialization
- Time allocation.

2.3: Requirements
- Programme entry requirements
- Time requirements (i.e. programme duration, teaching hours, study hours)
- Certificate requirements (i.e. credits, passing and failing conditions, compensation options).

2.4: Assessment
- Nature of assessment (i.e. number, type, duration, question types, availability of marks)
- Assessment model (i.e. relative weighting of assessments to overall grades).

2.5: Student learning pathways
- Degree of specialization
- Options in subject (area) choice (i.e. compulsory subjects, electives).

**RQ3:** To what degree do the subjects[5] align with regards to:

3.1: Content
- Topics (i.e. scope of content area, breadth, depth)
- Learning activities (i.e. difficulty, demand).

3.2: Expected learning outcomes
- Knowledge
- Competencies (i.e. subject-specific, 21st century competencies).

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 Canadian (Ontario) Curriculum*

| DP subject (group) | Canadian (Ontario) subjects |
|---|---|
| *SCIENCES* | |
| biology SL and HL | biology |

[5] With regards to subjects within scope, see Table below.

| | |
|---|---|
| chemistry SL and HL | chemistry |
| physics SL and HL | physics |
| *MATHEMATICS* | |
| mathematics: analysis and approaches SL and HL | Grade 9 De-streamed<br><br>Grade 10 Foundations of Mathematics<br>Grade 10 Principles of Mathematics<br><br>Grade 11 Functions, University Preparation<br>Grade 11 Functions and Applications, University/College Preparation<br><br>Grade 12 Advanced Functions, University Preparation<br>Grade 12 Calculus and Vectors, University Preparation<br>Grade 12 Mathematics of Data Management, University Preparation |
| mathematics: applications and interpretation SL and HL | |

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

## 2.3 Report Structure

In responding to the above RQs, this report included 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 Ontario upper secondary curriculum. In doing so, it includes brief programme overviews for both qualifications, 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 DP and Ontario upper secondary curriculum subjects. 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 top-level conclusion on alignment at both programme and subject levels, and a succinct summary of key similarities and key differences.

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

### OSSD Documentation

- Ontario Curriculum and Resources (website), including information about underpinning philosophy and pedagogy
- The Ontario Curriculum – Secondary Subjects Guides:
    - science (grades 9 and 10)
    - biology (grades 11 and 12)
    - chemistry (grades 11 and 12)
    - physics (grades 11 and 12)
    - mathematics grade 9 (de-streamed, online)
    - mathematics (grade 10)
    - mathematics (grades 11 and 12)

### Philosophical Underpinnings Comparison

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

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

| Documentation containing philosophical underpinnings | |
|---|---|
| **DP** | **OSSD** |
| 'What is an IB Education', particularly the following sections:<br>○ IB learner profile<br>○ International-mindedness<br>○ Approaches to teaching and approaches to learning (ATL).[6] | Government of Ontario School Curriculum and Resources website, particularly the following sections:<br>○ Transferrable Skills |

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

| | |
|---|---|
| | ○ Cross-curricular and integrated learning.[7] |

While the document 'What is an IB Education?' provides detailed information about the IB's educational philosophy, the philosophy and pedagogy of the OSSD are articulated to a lesser extent in the curriculum documentation available. Nevertheless, the 'Transferable Skills' and 'Cross-Curricular and Integrated Learning' sections of the OSSD website were deemed to provide sufficient detail for a meaningful comparison between the two programmes' philosophical underpinnings and were used as such.

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

### Learning Outcomes Comparison

For the Learning Outcomes comparisons, as neither of the two qualifications explicitly defines 'learning outcomes' in their curriculum documentation, Ecctis used the following categories of the curriculum documentation for comparison:

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

| **DP subject (group)** | **Categories utilised 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 | |
| **Canadian (Ontario) subjects** | **Documentation and Sections** |
| *SCIENCES* | |
| biology | Overall Expectations |
| chemistry | Overall Expectations |
| physics | Overall Expectations |
| *MATHEMATICS* | |
| Grade 9 Mathematics De-streamed | Mathematical Process Expectations<br>Grade 9 – Expectations by Strand (A and AA)* |
| Grade 10 Foundations of Mathematics | |
| Grade 10 Principles of Mathematics | |
| Grade 11 Functions, University Preparation | |
| Grade 11 Functions and Applications | |
| Grade 12 Advanced Functions | |
| Grade 12 Calculus and Vectors | |
| Grade 12 Mathematics of Data Management | |

*'Mathematical Process Expectations' were common to all mathematics subjects in the OSSD curriculum, while the 'Grade 9 – Expectations by Strand' are specific to the grade 9 mathematics subject. For the latter, both strands A and AA were included for review, as these were deemed to provide important complementary information on non-content specific skills.

[7] Government of Ontario, Ministry of Education. (2020). *Curriculum and Resources.* https://www.dcp.edu.gov.on.ca/en/

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 OSSD. 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 (in this case, the OSSD). 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.

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 specifically asked Ecctis to consider alignment from the 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
    - Alignment of approaches to assessment.

- 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 Ontario, it sought to:

- Analyse to what extent the OSSD has similarities with the DP.
- Analyse to what extent the OSSD lacks features contained within the DP.
- Analyse to what extent the DP lacks features contained within the OSSD.

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 OSSD, 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 OSSD (the comparison programme) 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

In the DP, the ATL, the learner profile, and the framework of international-mindedness were used to represent the philosophical underpinnings, while the 'Transferrable Skills' and 'Cross-curricular and Integrated Learning' sections were used for the OSSD.

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 OSSD to identify what aspects of the DP's philosophical underpinnings are shared with the OSSD and what aspects are unique to either the OSSD'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 does not require a mapping process. Instead, subject offerings, how duration interacts with subjects/progression, and the general structure of the qualification (including exit points) have been represented with visuals for each programme. These curriculum structure diagrams use block colours and simple box and arrow graphics to demonstrate structure and progression.

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 of the two programmes.

### Requirements and Associated Outcomes

The requirements and associated outcomes of each programme 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) linked to both programmes and the associated outcomes of both.

### 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. As with the comparative analysis of structure, diagrams resembling flow charts have been used to visually demonstrate the core and optional subject choices, providing an example to indicate how students follow different potential learning pathways in both programmes. A short textual write-up has been included after the diagrams to highlight and discuss the key similarities and differences – maintaining analytical focus on the issue of alignment.

### Assessment Methods

Although detailed comparative analysis of assessment is not a main component of the analysis of alignment, Ecctis has briefly considered the high-level assessment features within the programmes being compared.

A simple table has been used, followed by a short textual description of the key similarities and differences. The types/numbers of assessment used in the programme are a source of comparison, and the subjects analysed in the subject-level alignment analysis in each report have been used as examples to consider assessment in more detail (i.e. question types and marking approaches, where this information is available).

## 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 OSSD.

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 OSSD and any knowledge areas and skills found in the OSSD but not in DP.

### Content

To compare the content of the DP subject and the comparison OSSD 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 OSSD 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 OSSD subject and on OSSD 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 report. 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 course 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.[8]

- **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 level of detail studied per topic, as well as the levels of thinking described in Webb's Depth of Knowledge framework.[9]

- **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
  b. depth of content – i.e. the extent to which the topics and sub-topics are focused upon, amplified and explored.[10]
  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'.

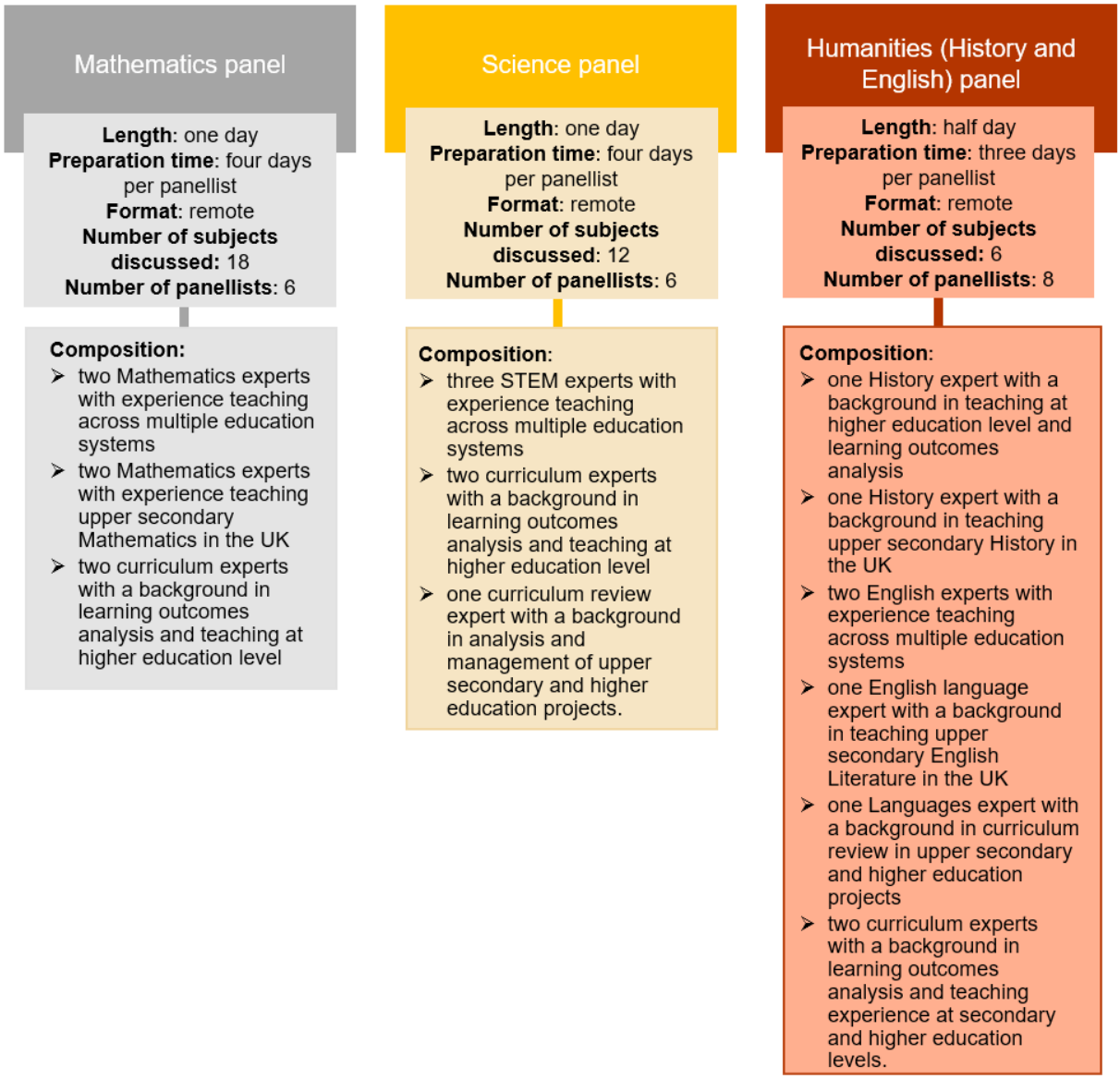
*Demand Panel: Expert Judgement Procedure*

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.[11]

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:

[8] 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
[9] Webb, N. L. (2002). *Depth-of-knowledge levels for four content areas*. Language Arts. Microsoft Word - Webb DOK all content.doc (pbworks.com)
[10] 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).
[11] 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*




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.[12]

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.

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

# 4. Programme-Level Alignment

This section focuses on answering RQ2 and the sub-questions associated with it, namely:

*Table 6: Research question 2*

**RQ2:** To what degree do the curricula align with regards to their:
2.1: Philosophical underpinnings
- Objectives
- Principles
- Values?

2.2: Structure
- Learning areas
- Subject offerings
- Degree of specialization
- Time allocation?

2.3: Requirements
- Programme entry requirements
- Time requirements (i.e. programme duration, teaching hours, study hours)
- Certificate requirements (i.e. credits, passing and failing conditions, compensation options)?

2.4: Assessment
- Nature of assessment (i.e. number, type, duration, question types, availability of marks)
- Assessment model (i.e. relative weighting of assessments to overall grades)?

2.5: Student learning pathways
- Degree of specialization
- Options in subject (area) choice (i.e. compulsory subjects, electives)?

It starts by offering top-level overviews of both the DP and the OSSD, followed by presenting the results from the programme-level comparative analysis for each core component outlined above.

## 4.1 Programme Overviews

### 4.1.1 The International Baccalaureate Diploma Programme

The Diploma Programme (DP) was established in 1968 as a two-year pre-university programme for 16–19-year-old students.[13]

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

- Studies in language and literature
- Language acquisition
- Individuals and societies
- Sciences
- Mathematics

[13] DP *From Principles into Practice* (2015), p. 5.

- The arts.[14]

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 course instead.

All subjects are studied concurrently over the two-year duration of the programme and 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.[15]

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.[16] The extended essay is a self-directed piece of research which results in a 4000-word essay.[17] 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.[18] Together, these three components comprise the DP 'core'.

To achieve the IB Diploma a student must take at least three HL subjects.[19] 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.[20]

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.

[14] International Baccalaureate. (2021). *Curriculum*. https://www.ibo.org/programmes/diploma-programme/curriculum/
[15] Ibid.
[16] International Baccalaureate. (2021). *Theory of knowledge*. https://www.ibo.org/programmes/diploma-programme/curriculum/theory-of-knowledge/

[17] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 2.
[18] International Baccalaureate. (2021). *CAS projects.* https://www.ibo.org/programmes/diploma-programme/curriculum/creativity-activity-and-service/cas-projects/
[19] International Baccalaureate. (2021). *Curriculum*.
[20] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 6.

*Figure 2: IB Diploma Programme curriculum model*[21]


Both internal and external assessment methods are used in the DP. In most subjects, students take written examinations at the end of the programme that are marked by external IB examiners. Internally assessed tasks normally comprise between 20-30% of the total mark in each subject.[22]

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.[23] Coursework forms part of the assessment for areas of the DP such as the extended essay and TOK.[24] 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.[25] Some of the internal assessment methods used include oral work in languages, fieldwork in geography, laboratory work in the sciences, and artistic performances in the arts.[26]

Each DP subject, whether taken at SL or HL, is graded from 1-7 (with 7 representing the highest achievement level).[27] If a student has taken enough subjects at the correct level to be

[21] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 2.
[22] International Baccalaureate. (2021). *Understanding DP assessment*. https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/understanding-ib-assessment/; International Baccalaureate. (2014). *Diploma Programme: A guide to assessment*. p. 3.
[23] International Baccalaureate. (2021). *Assessment and Exams*. https://www.ibo.org/programmes/diploma-programme/assessment-and-exams/
[24] International Baccalaureate. (2021). *Understanding DP assessment*.
[25] Ibid.
[26] International Baccalaureate. (2021). *Assessment and Exams*.
[27] International Baccalaureate. (2021). *Understanding DP assessment*.

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.[28]

Additionally, 42 total 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.[29] Their combined results can contribute up to three additional numerical points to the overall DP score (see Table below). CAS does not constitute a graded part of the DP, although its completion is mandatory to be awarded the Diploma.

HL and SL subjects are assessed against the same grade descriptors;[30] 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.[31] 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.

*Table 7: Letter-Grade: numerical score conversion matrix*[32]

| | | Theory of knowledge (TOK) | | | | |
|---|---|---|---|---|---|---|
| | **Grade awarded** | A | B | C | D | E |
| **The extended essay** | A | 3 | 3 | 2 | 2 | Failing condition |
| | B | 3 | 2 | 2 | 1 | |
| | C | 2 | 2 | 1 | 0 | |
| | D | 2 | 1 | 0 | 0 | |
| | E | Failing condition | | | | |

No formal entrance requirements are stipulated as the IB envisages numerous educational pathways leading to the DP.[33] However, the IB recommends consulting the subject guides prior to enrolment to ensure an adequate understanding of programme expectations.[34]

[28] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 4.
[29] Ibid.
[30] International Baccalaureate. (2021). *Understanding DP assessment*.
[31] International Baccalaureate. (2016) *Guide to the International Baccalaureate Diploma Programme*. p. 4.
[32] International Baccalaureate. (2017). *Assessment principles and practices: Quality assessments in a digital age*. p. 220.
[33] International Baccalaureate. (2015). *Diploma Programme: From principles into practice*. p. 22.
[34] Ibid.

### 4.1.2 Ontario Secondary School Diploma

The school system in the Canadian province of Ontario is overseen by The Ontario Ministry of Education. It is divided into primary school (grades 1-8) and secondary school (grades 9-12), with each grade being a year in duration.[35]

#### Structure

The Ontario Secondary School Diploma (OSSD) spans the four years of Ontario's secondary school education, grades 9-12. Beginning in grade 9, students take courses to earn credits towards the OSSD, which is intended to grant access to higher education upon successful completion. There are several credit, and other, requirements, to gain the OSSD (covered in detail in the sections below). Courses are not only categorised by subject, but also by the stream within which they sit. Indeed, streaming is a key feature of the OSSD structure, with many subjects containing different streams that are based on students' associated outcomes. Types of courses include:

- Grades 9 and 10 courses – these will either be 'Academic', 'Applied', or 'Open'. More recently, some subjects that were previously streamed in grade 9 have now been 'de-streamed'.[36]
- Grades 11 and 12—courses are either 'University Preparation', 'College Preparation', 'University/College Preparation', 'Workplace', or 'Open'.

Students often need to have taken courses from a particular stream to have the right pre-requisites for a course in a later grade. For example, grade 12 Advanced Functions (university) has the pre-requisite of grade 11 Functions (university). Broadly, grade 12 courses will have the pre-requisite of the corresponding grade 11 course from the same stream. Typically, though not always, university courses will have academic pre-requisites, college courses will have applied pre-requisites, university/college courses will accept either, and workplace courses will have applied, de-streamed, or open pre-requisites. A number of courses do not have any pre-requisites, such as grade 12 Child Development and Gerontology (college).

#### Credit Requirements

To earn a high school diploma in Ontario, students must:

- Earn a minimum of 30 credits, including 18 compulsory credits (see table below) and 12 optional credits selected from the courses listed as available in their school's programme and course calendar.
- Meet the provincial secondary school literacy requirement (i.e. usually, this means passing the Ontario Secondary School Literacy Test[37])
- Complete a minimum of 40 hours of community involvement activities (a requirement aimed to provide students the opportunity to develop awareness and understanding about civic responsibility).[38]

[35] Government of Ontario, Ministry of Education. (2020). *Education and Training*. https://www.ontario.ca/page/educationand-training

[36] Meaning that, for grade 9 core courses, students no longer choose between the Academic and Applied levels.

[37] Education Quality and Accountability Office. (n.d.). *Ontario Secondary School Literacy Test (OSSLT).* https://wwweqao.com/the-assessments/osslt/

[38] Government of Ontario, Ministry of Education. (2020). *High school graduation requirements*. https://www ontario.ca/page/high-school-graduation-requirements#section-3

Additionally, candidates who successfully complete a Specialist High Skills Major (SHSM) course as part of the requirements for their OSSD will earn a specialised diploma featuring a SHSM red seal.[39]

The OSSD includes courses for grades 9 to 12 for the following subjects and disciplines:

*Table 8: OSSD list of courses for grades 9 to 12[40]*

| OSSD list of courses for grades 9 to 12 |
|---|
| • The Arts<br>• Business Studies<br>• Canadian and World Studies<br>• Classical Studies and International Languages<br>• Computer Studies<br>• Cooperative Education<br>• English<br>• English as a Second Language and English Literacy Development<br>• First Nations, Métis, and Inuit Studies<br>• French as a Second Language<br>• Guidance and Career Education<br>• Health and Physical Education<br>• Mathematics<br>• Native Languages (to be renamed Indigenous Languages)<br>• Science<br>• Social Sciences and Humanities<br>• Technological Education |

To successfully complete the OSSD, students must earn the following 18 compulsory credits:

*Table 9: Compulsory credits for attaining the OSSD*

| Compulsory credits for attaining the OSSD (Total of 18) |
|---|
| • 4 credits in English (1 credit per grade)<br>• 3 credits in mathematics (at least 1 credit in grade 11 or 12)<br>• 3 credits for group 1, 2 and 3 courses (1 credit in each group)<br>• 2 credits in science<br>• 1 credit in Canadian history (grade 10)<br>• 1 credit in Canadian geography (grade 9)<br>• 1 credit in the arts<br>• 1 credit in health and physical education<br>• 1 credit in French as a second language<br>• 0.5 credit in career studies<br>• 0.5 credit in civics and citizenship |

Of these 18 compulsory credits, students must complete at least one from each of three groups:

[39] Government of Ontario, Ministry of Education. (2016). *Ontario Schools, Kindergarten to Grade 12: Policy and Program Requirements*. http://www.edu.gov.on.ca/eng/document/policy/os/onschools_2016e.pdf
[40] Government of Ontario, Ministry of Education. (2018). *The Ontario Curriculum. Grades 9 to 12. Course Descriptions and Prerequisites*. http://www.edu.gov.on.ca/eng/document/curricul/secondary/descript/descri9e.pdf

*Table 10: Subjects per relevant group in the OSSD*[41]

| | |
|---|---|
| Group 1 | • English (including the Ontario Secondary School Literacy Course) or French as a second language<br>• Native languages<br>• First Nations, Métis, and Inuit studies<br>• Classical and international languages<br>• Social sciences and the humanities<br>• Canadian and world studies<br>• Guidance and career education<br>• Cooperative education<br>• American Sign Language as a second language<br>• Langue des signes québécoise langue seconde |
| Group 2 | • Health and physical education<br>• The arts<br>• Business studies<br>• French as a second language<br>• Cooperative education<br>• American Sign Language as a second language<br>• Langue des signes québécoise langue seconde |
| Group 3 | • Science (grade 11 or 12)<br>• Technological education<br>• French as a second language<br>• Computer studies<br>• Cooperative education<br>• American Sign Language as a second language<br>• Langue des signes québécoise langue seconde |
| NB: Two additional conditions apply to the selection of compulsory credits from groups 1, 2 and 3:<br>• A maximum of two credits in French as a second language can count as compulsory credits (one from group 1 and one from either group 2 or group 3).<br>• A maximum of two credits in Cooperative education can count as compulsory credits, selected from any of the above three groups. | |

Each credit is granted to students who successfully complete, by achieving a mark of 50% or higher, a course that has been scheduled for a minimum of 110 hours. For two-part ministry-developed courses lasting at least 110 hours in total, students can be granted half a credit (0.5) for each part.

In addition to the 18 compulsory credits, students must complete 12 optional credits selected from the courses listed as available in their school's programme and course calendar. They must also meet the secondary school literacy graduation requirement, usually acquired by taking the Ontario Secondary School Literacy Test (OSSLT) in grade 10 (though alternative routes are available for mature students and those who do not successfully complete the OSSLT).[42]

Students must also complete a minimum of 40 hours of community involvement activities as part of the diploma requirements, with the intention of developing students' awareness and understanding of civic responsibility and their role within their communities. This diploma requirement applies to students in grades 9 to 12, and students in grade 8 can start

[41] Government of Ontario, Ministry of Education. (2020). *High School Graduation Requirements*. https://www.ontario.ca/page/high-school-graduation-requirements#section-3
[42] Ibid.

accumulating community involvement hours in the summer before they enter grade 9. Mature students' community involvement hourly requirement is determined on a case-by-case basis.[43]

### Assessment

All assessment within the Ontario school system, from grade 1 to grade 12, is guided by seven underlying principles, stating that teachers should follow practices and procedures that:

- 'are fair, transparent, and equitable for all students;
- support all students, including those with special education needs, those who are learning the language of instruction (English or French), and those who are First Nation, Métis, or Inuit;
- are carefully planned to relate to the curriculum expectations and learning goals and, as much as possible, to the interests, learning styles and preferences, needs, and experiences of all students;
- are communicated clearly to students and parents at the beginning of the school year or course and at other appropriate points throughout the school year or course;
- are ongoing, varied in nature, and administered over a period of time to provide multiple opportunities for students to demonstrate the full range of their learning;
- provide ongoing descriptive feedback that is clear, specific, meaningful, and timely to support improved learning and achievement;
- develop students' self-assessment skills to enable them to assess their own learning, set specific goals, and plan next steps for their learning'.[44]

In terms of types of assessment conducted at secondary level, the Ontario system takes a highly flexible approach to assessment. 70% of the final mark of each course is based on evaluation conducted internally throughout the course, while 30% is based on a final internal evaluation conducted towards the end of the course and which can assume the form of 'an examination, a performance, an essay, and/or another method of evaluation suitable to the course content'. At secondary level, assessments are exclusively internal (as opposed to external examinations common in other systems), with the exception being the OSSLT – the external evaluation carried out by the Education Quality and Accountability Office to assess whether students meet the literacy requirement for graduation.[45]

### Alternative Awards to the OSSD in Ontario's Secondary Education System

*The Ontario Secondary School Certificate:*

The Ontario Secondary School Certificate (OSSC) can be requested by students who are leaving secondary school upon reaching the age of 18 without having met the requirements for the OSSD. To be granted an OSSC, the candidate must have earned a minimum of 14 credits, including seven compulsory credits.[46]

*The Certificate of Accomplishment:*

Students who are leaving secondary school upon reaching the age of 18 without having met the requirements for the OSSD or the OSSC may be granted a Certificate of Accomplishment,

[43] Ibid.
[44] Government of Ontario, Ministry of Education. (2010). *Growing Success: Assessment, Evaluation, and Reporting in Ontario Schools.* http://www.edu.gov.on.ca/eng/policyfunding/growSuccess.pdf
[45] Education Quality and Accountability Office. (n.d.). *Ontario Secondary School Literacy Test (OSSLT).*
[46] Ibid.

accompanied by the student's Ontario Student Transcript. Where applicable, a copy of the students' Individual Education Plan (IEP) may be included.

### Curriculum Design Principles

In terms of curriculum design principles, articulated in the 'Transferable skills' and 'Cross-curricular and integrated learning' sections of the Curriculum and Resources website, the Ontario secondary programme prioritises the development of skills and learning in areas that 'are critical to students in navigating the world'.[47] Such themes, perspectives and skills currently include:

*Table 11: Transferable skills and cross-curricular and integrated learning in the OSSD.*[48]

| Transferable skills | Cross-curricular and integrated learning |
|---|---|
| • Critical thinking and problem solving<br>• Innovation, creativity, and entrepreneurship<br>• Self-directed learning<br>• Collaboration<br>• Communication<br>• Global citizenship and sustainability<br>• Digital literacy | • Environmental education<br>• Indigenous education<br>• Financial literacy<br>• Social-emotional learning<br>• Critical literacy<br>• Mathematical literacy<br>• STEM education. |

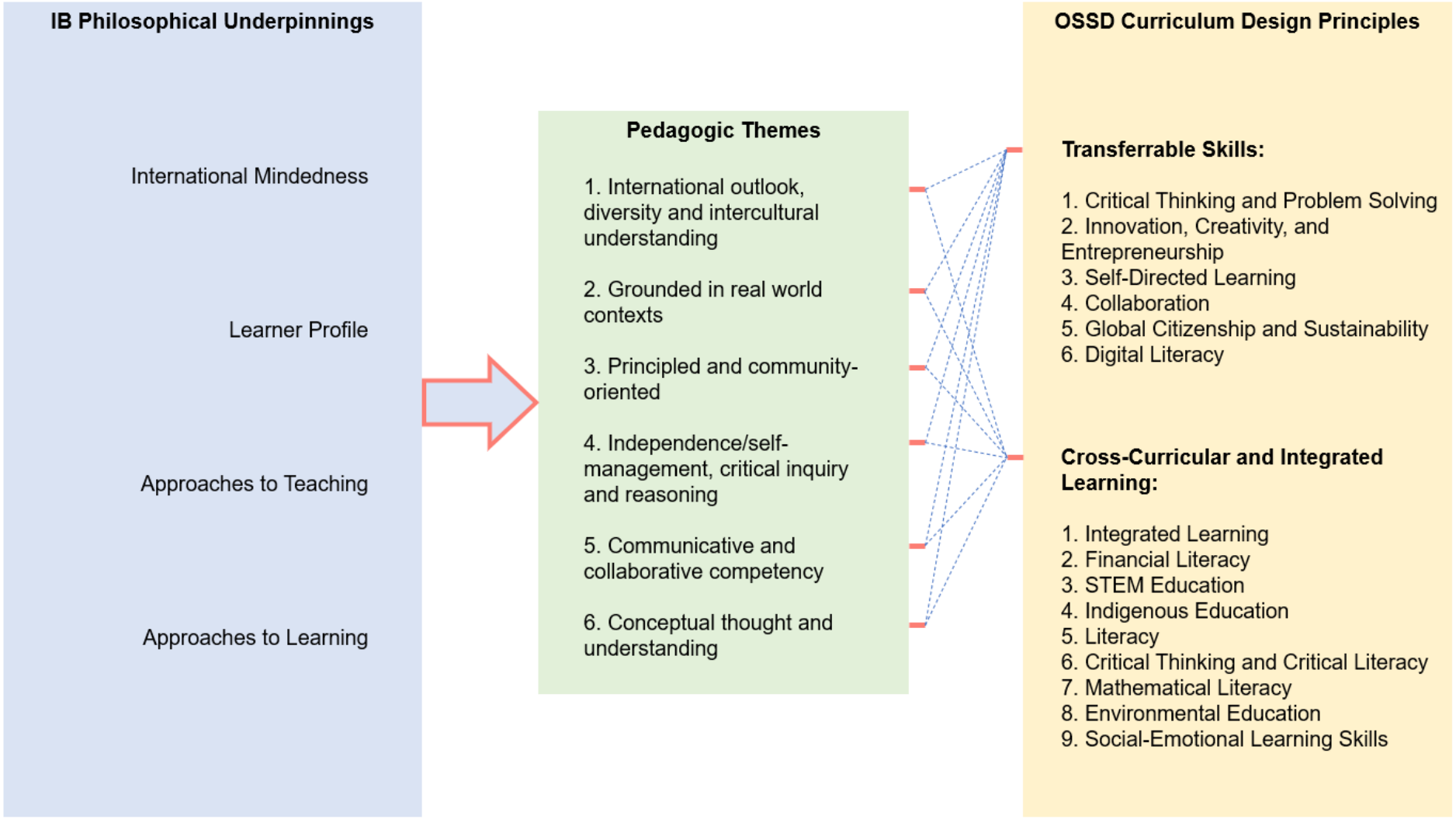
These various themes, perspectives, and skills are part of a vision to develop students that are able to successfully navigate 'a world that is more competitive, more globally connected, and more technologically engaged than it has been in any other period of history', by preparing them for 'job flexibility, frequent career re-orientation, and work and civic life in a globalized, digital age'.[49]

This approach is complemented by a strong civic focus, best exemplified by the requirement to complete a minimum of 40 hours of community involvement activities in order to graduate. According to the *Ontario Schools Kindergarten to grade 12 – Policy and Program Requirements* document, the purpose of this requirement is to 'encourage students to develop an awareness and understanding of civic responsibility and of the role they can play and the contributions they can make in supporting and strengthening their communities'.[50]

[47] Government of Ontario, Ministry of Education. (2020). *Cross-curricular and integrated learning*. https://www.dcp.edu.gov.on.ca/en/program-planning/cross-curricular-and-integrated-learning/introduction
[48] Government of Ontario, Ministry of Education. (2020). *High School Graduation Requirements*.
[49] Ibid.
[50] Government of Ontario, Ministry of Education. (2016). *Ontario Schools, Kindergarten to Grade 12: Policy and Program Requirements*.

## 4.2 Philosophical Underpinnings

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



The IB learner profile, which is used across all IB programmes including the DP, outlines 10 attributes that all students should strive towards.[51] 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.

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

*Table 12: 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 |

When mapping the six DP themes onto the OSSD curriculum design principles, it is apparent that all DP themes are strongly present in the Ontario context. All the themes are comprehensively covered across the component parts of the OSSD curriculum design principles, indicating that the Ontario curriculum operates on similar philosophical underpinnings to the IB curriculum.

The main difference identified between both programmes is the OSSD's specific focus on the Canadian national context, requiring students to have awareness of Canadian and indigenous peoples' contributions to knowledge and 'develop a sense of identity in the context of Canada's various and diverse communities'.[52] This country-specificity is absent from the DP, given its global essence and focus.

Another potential difference identified between the two is the level of detail provided. While both programmes share very similar pedagogical principles, the OSSD's 'Cross-Curricular Integrated Learning' framework was found to be more prescriptive in its formulation of some of these principles. For instance, while the DP's philosophical underpinnings do emphasise the development of linkages to real-world contexts – e.g., 'engage with issues and ideas that have local and global significance'[53] – the Ontario curriculum design principles provide more

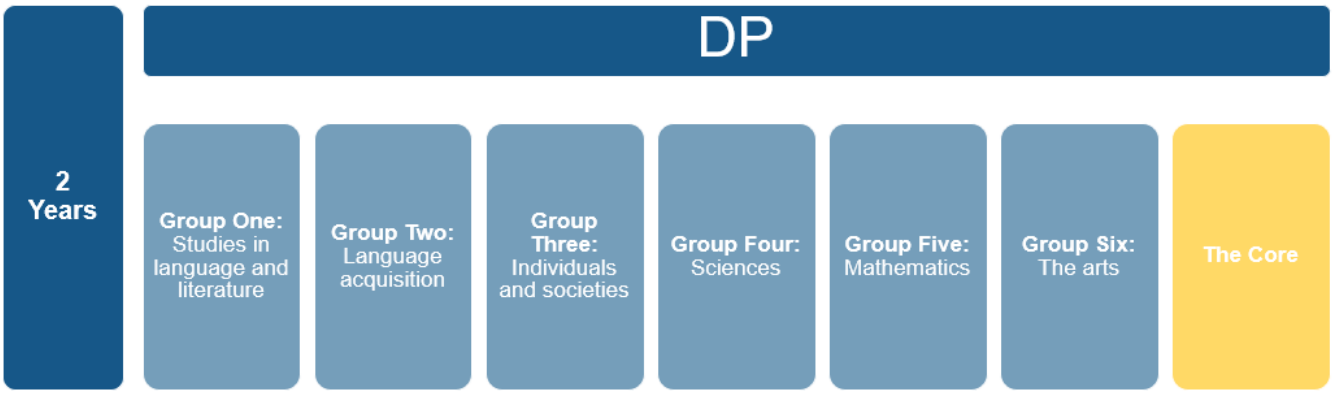
[51] International Baccalaureate. (2017). *What is an IB education?*
[52] Government of Ontario, Ministry of Education. (2020). *Curriculum and Resources.* https://www.dcp.edu.gov.on.ca/en/
[53] Ibid.

detail on what those local, national and global issues and ideas may be – i.e. it specifically prioritises environmental education, equity and inclusive education, indigenous education, financial literacy education, and collaborative professionalism.[54] In this sense, while both programmes share similar philosophical principles, there appears to be more flexibility within the DP for these to be applied differently by different schools, while schools offering the OSSD may find that they need to cover a more specific set of themes to ensure philosophical alignment with the prescribed curriculum. However, the DP subject guides also provide more detailed guidance on how to make links to the IB's philosophy, potentially bringing the two programmes even closer together in practice.

## 4.3 Structure

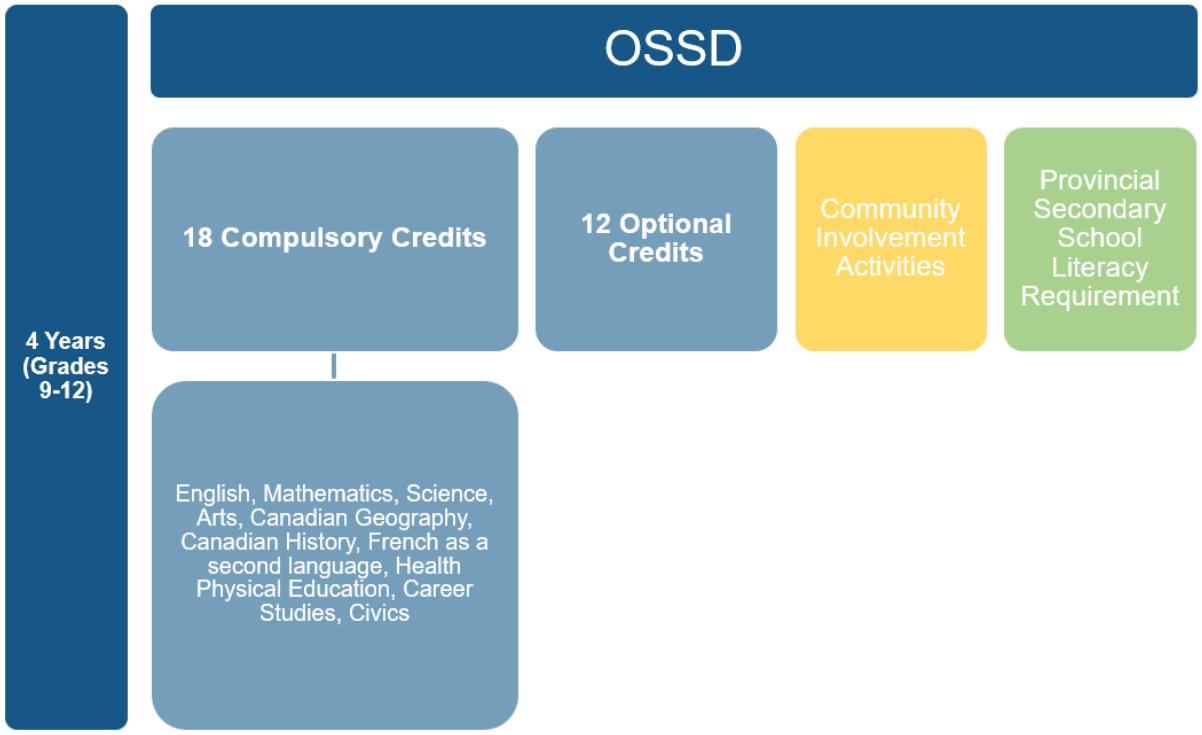
There are six subject groups comprising the DP and students pursuing the Diploma award are normally required to select one subject from each of the six groups.[55] The DP also has three core components which are compulsory and are carried out alongside subjects. The OSSD includes seventeen subject areas as well as community work. In order to get their OSSD, students must earn eighteen compulsory credits in the following ten subjects: English (4 credits, 1 credit per grade); mathematics (3 credits, with at least 1 from grades 11 or 12), 3 credits from group 1, 2 and 3 courses (1 credit in each group); science (2 credits); Canadian history (grade 10, 1 credit); Canadian geography (grade 9, 1 credit); arts (1 credit); health and physical education (1 credit); French as a second language (1 credit); career studies (0.5 credit), and civics and citizenship (0.5 credit). Apart from the eighteen credits in the compulsory subjects, students also need to get twelve optional credits selected from the courses available. The figures below present the subject groups of the DP in comparison with the subjects that cover similar areas of learning in the OSSD.

*Figure 4: Structural overview of the DP*




[54] Government of Ontario, Ministry of Education. (2016). *Ontario Schools, Kindergarten to Grade12: Policy and Program Requirements.*
[55] International Baccalaureate. (2021). *How the Diploma Programme works*. https://www.ibo.org/programmes/diploma-programme/what-is-the-dp/how-the-diploma-programme-works/

*Figure 5: Structural overview of the OSSD*




In terms of similarities in the programme structure and subjects taught, both programmes follow a baccalaureate-style approach, prioritising breadth; both include many similar subjects in their programmes of study; and both programmes have their subjects organised into subject groups.

Subjects common to both the DP and the OSSD are languages (including a variety of classical and modern languages), history, science, maths, arts, geography, business studies and management, information technology and physical education. Additionally, both programmes include social, cultural, political, religious and humanities subjects. Furthermore, both programmes have one curriculum component which requires students' involvement in community activities, namely CAS in the DP and Community Involvement Activities in the OSSD. In the DP, CAS does not constitute a graded part, although its completion is mandatory to receive the award of the Diploma. Similarly, Community Involvement Activities in the OSSD are mandatory for all students as part of the Diploma, requiring students to complete a minimum of 40 hours.

Regarding differences in the structure of the programme of study, DP students can study the six chosen disciplines concurrently, with the subjects being offered at two levels: SL and HL. This division in levels is not offered in the OSSD, which offers different streams instead. Similarly to SL and HL, however, streams will differ in difficulty. Although both programmes outline the teaching hours of individual subjects, with OSSD also stating the number of credits for each course, a difference between the programmes is in the number of subjects that students need to achieve to get each diploma. In the DP, students must complete six subjects – up to four at higher level – and achieve a minimum pass grade of 3 in all of them. The recommended teaching hours per subject, as outlined in the DP curriculum documentation,

are 150 at standard level and 240 at higher level.[56] In OSSD, students must earn, over four years, a minimum of 30 credits, including 18 compulsory credits and 12 optional credits, selected from the courses listed as available in their school's programme and course calendar. Each credit in the OSSD should comprise 110 teaching hours.

Another requirement of the OSSD is that the students must meet the provincial secondary school literacy requirements. There are no state literacy requirements in the DP, due to its nature as an international programme.

Another difference between the two programmes is that the TOK and the extended essay core components are only evident in the DP and the OSSD does not include any similar courses. The OSSD includes the subjects of career studies and cooperative education. Similar subjects on these topic areas are not included in the DP.

## 4.4 Requirements and Associated Outcomes

Regarding entry requirements, there are no formal entrance requirements stipulated for the DP as the IB envisages numerous educational pathways leading to upper secondary education.[57] However, the IB recommends consulting the subject guides prior to enrolment to ensure an adequate understanding of programme expectations.[58] In the OSSD, some courses in grades 10, 11 and 12 have prerequisites for enrolment, outlined in the programme curriculum and policy documentation and schools are responsible for providing students clear information on the prerequisites of these courses. For example, the prerequisite for enrolment in the grade 11 Dance course (University or College preparation) is the completion of the grade 9 or 10 Dance course (Open). Another example includes the prerequisites for enrolment in International Language Level 2 (University preparation) which requires students to first complete the International Languages Level 1 (Academic). Similarly, students who want to enrol on the grade 11 Functions course (University preparation) must first complete grade 10 Principles of Mathematics (Academic).

In terms of associated outcomes, both programmes aim to prepare students for higher education and/or employment. According to the DP documentation, although the DP is conceived as a preparatory programme for university matriculation and higher education focusing primarily on rigorous academic study, the programme can also prepare students for employment. Similarly, the OSSD course documentation outlines the purpose of each course in preparing students for either university, college, or the workplace.

Both programmes intend for students to work towards a diploma at the end of their period of study (two years in the IB, four years in Ontario). However, both programmes also have flexible options to reward students with some form of certificate or evidence of accomplishment if they do not complete the full requirements of the respective diplomas.

[56] International Baccalaureate. (2021). *Curriculum*.
[57] International Baccalaureate. (2015). Diploma Programme: *From principles into practice*. p. 5.
[58] Ibid. p. 22.

## 4.5 Student Learning Pathways

In terms of learning pathways, both programmes include compulsory and optional subjects. See the programme overviews in section 4.1 for further details on subject selection. To understand the levels of optionality and potential specialisation in each programme, it is instructive to look at what an individual student would be able to choose in practice. The following diagrams demonstrate the subject options available to an imagined student who knows that they would like to study physics at university after the completion of their upper secondary studies.

*Figure 6: DP imagined pathway for a student wishing to study physics at university*

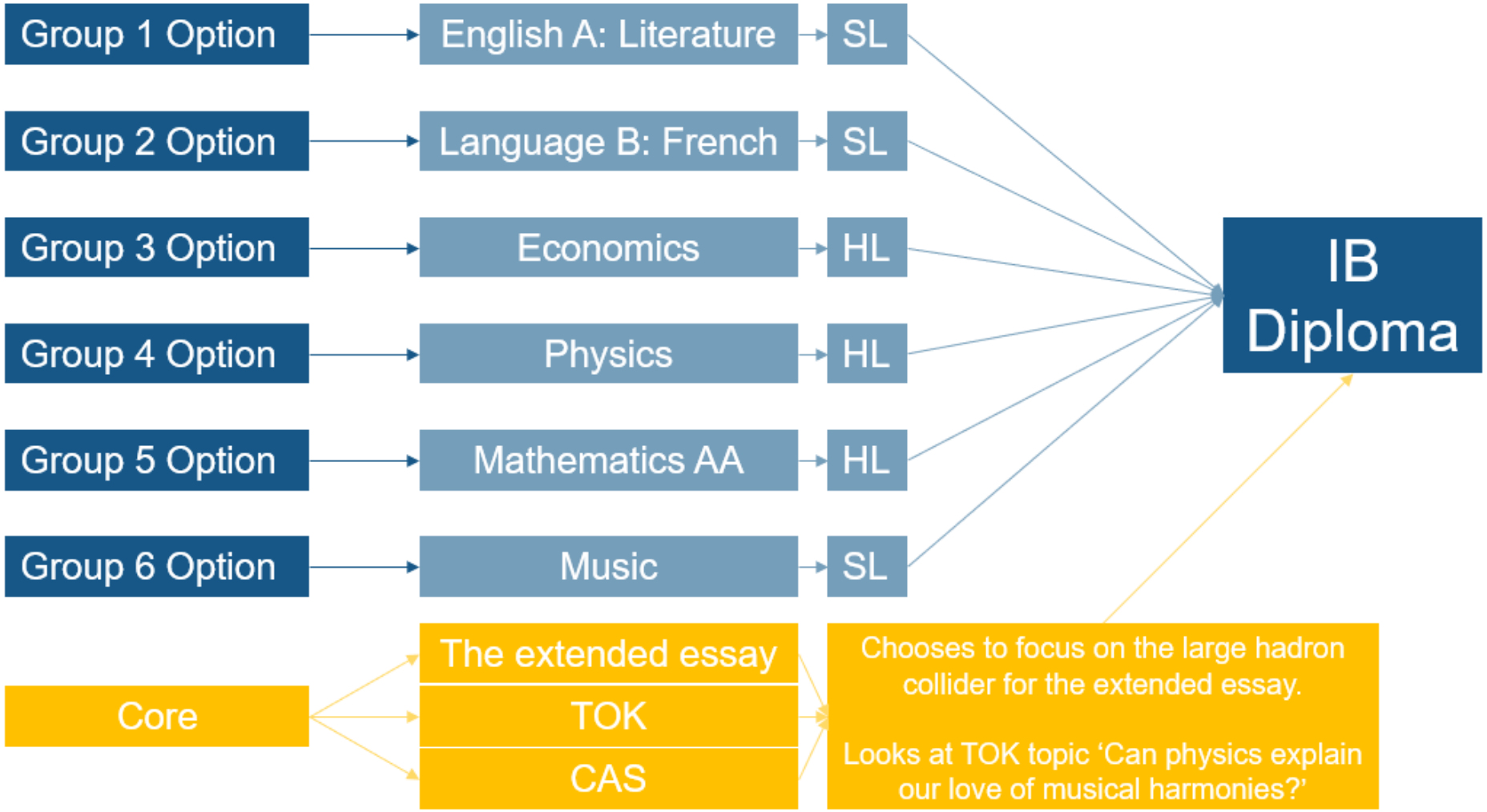
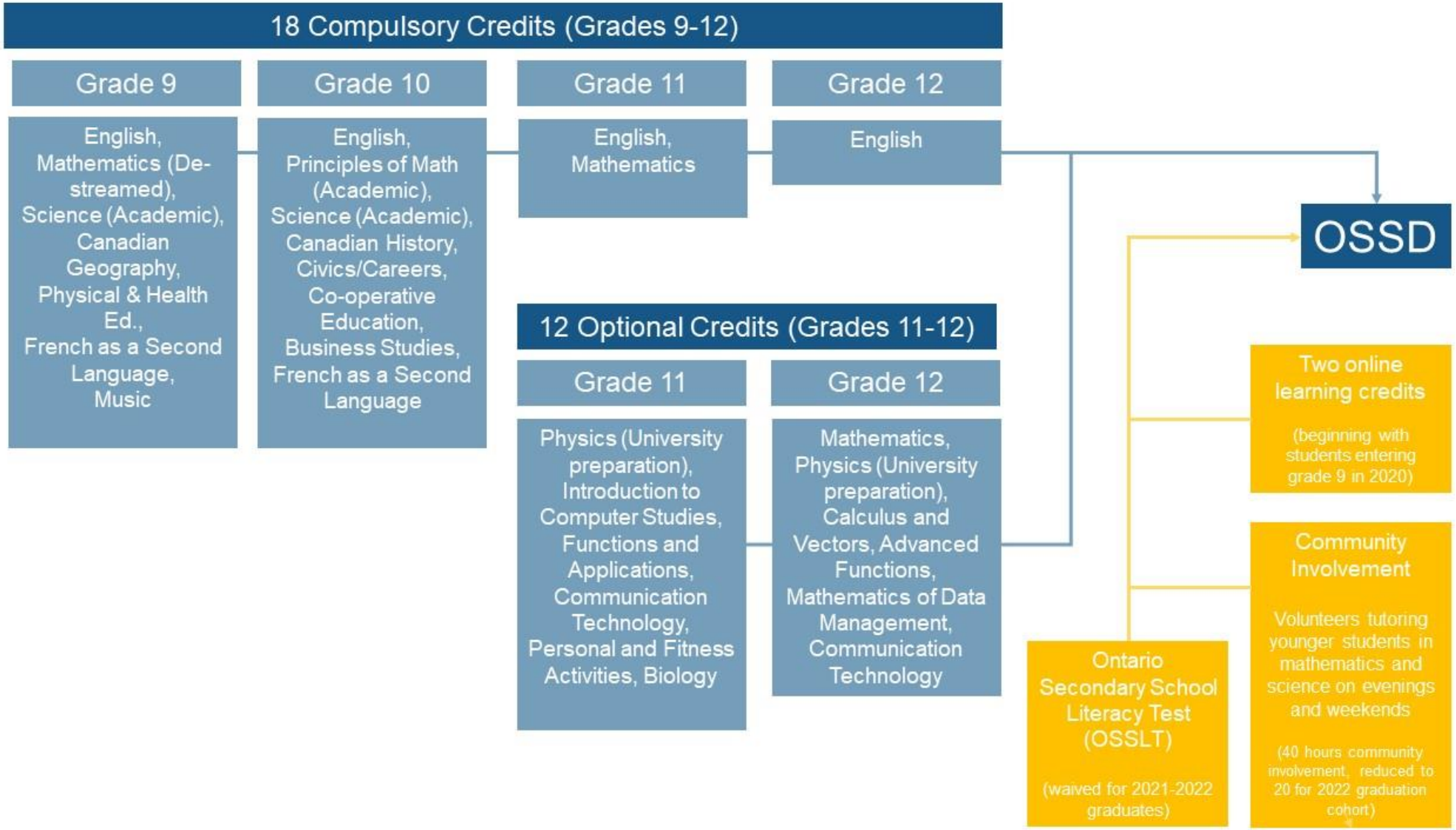


*Figure 7: OSSD imagined pathway for a student wishing to study physics at university*



One difference between the DP and the OSSD learning pathways is that in the OSSD students can explore a career path that matches their skills and interests while earning a Specialist OSSD named Specialist High Skills Major (SHSM). Students receive the SHSM in their area of interest when they complete a specific bundle of seven to nine credits (including two credits in Cooperative education), earn valuable industry sector recognized certifications (compulsory and electives), and develop important skills on the job through Cooperative education placements. A similar course is not offered in the DP, though the IB's Career-Related Programme (CP) gives students a vocational pathway through their upper-secondary education.

Another difference between the DP and OSSD in terms of learning pathways is that DP students who fulfil specific subject grade criteria can be awarded a bilingual Diploma. This option is not available in the OSSD.

There are alternative awards to the OSSD in Ontario's Secondary Education System including the Ontario Secondary School Certificate (OSSC) and the Certificate of Accomplishment. The OSSC can be requested by students who are leaving secondary school upon reaching the age of 18 without having met the requirements for the OSSD. To be granted an OSSC, the candidate must have earned a minimum of 14 credits. More specifically, these credits include seven compulsory credits from the subjects of English (two credits), mathematics (one credit), science (one credit), Canadian history or Canadian geography (one credit), health and physical education (one credit), and arts, computer studies or technological education (one credit), and seven required optional credits selected by the student from the available courses.[59] Regarding the Certificate of Accomplishment, students who are leaving secondary school upon reaching the age of 18 without having met the requirements for the OSSD or the OSSC may be granted a Certificate of Accomplishment, accompanied by the student's Ontario Student Transcript. Where applicable, a copy of the students' IEP may be included. Similarly, in the DP, certificates are awarded to students that have taken individual subjects but not enrolled on the full DP.[60]

## 4.6 Assessment Methods

This section looks at the key features of assessment in both programmes by using a simple table followed by a short textual description of the key similarities and differences.

[59] Government of Ontario, Ministry of Education. (2016). *Ontario Schools, Kindergarten to Grade 12: Policy and Program Requirements*.
[60] International Baccalaureate. (2016). *Guide to the International Baccalaureate Diploma Programme*. p. 4.

*Table 13: Top level assessment comparisons*

| | DP | Ontario |
|---|---|---|
| **External assessment** | ✓ | ✗ |
| *Weighting* | Varies by subject | 0% |
| Mathematics | **SL & HL**: 80% | N/A |
| Sciences | **SL & HL**: 80% | N/A |
| *Methods* | Exam<br>(Typically, two-three exam papers per subject) | N/A |
| Mathematics | **SL**: 2 papers of 90 minutes in duration each, with 80 marks available in each.<br>**HL**: 3 papers with durations of 120, 120, and 60 minutes. Marks available are 110, 110, and 55.<br><br>**Question Types**: compulsory short-response and extended response questions, incorporating problem solving in HL paper 3. | N/A |
| Sciences | **SL**: 3 papers worth 20%, 40%, and 20% of total weighting, with duration of 45, 75, and 60 minutes each.<br><br>**HL**: 3 papers worth 20%, 36%, and 24% of total weighting, with duration of 60, 135, and 75 minutes each.<br><br>**Question Types**: multiple choice, short and extended response, data-based and experiment-based; some optionality in paper 3. | N/A |
| **Internal assessment** | ✓<br>(Often used) | ✓<br>(Used in all subjects) |
| *Weighting* | Varies by subject | 100% |
| Mathematics | **SL & HL**: 20% | 70% of final grade stems from evaluations conducted throughout the course. 30% stems from a final evaluation in the form of examination or other suitable method. |
| Sciences | **SL & HL**: 20% | 70% of final grade stems from evaluations conducted throughout the course. 30% stems from a final evaluation in the form of examination or other suitable method. |
| *Methods* | Vary by subject but should follow IB guidance. | Vary by subject but should be designed around learning outcomes. |
| Mathematics | **SL & HL**: A 'mathematical exploration' involving a piece of written work for 20 marks. | Combination of approaches designed by schools and teachers. |
| Sciences | A practical, individual investigation with 10 hours duration and 6-12 pages of write-up. | Combination of approaches designed by schools and teachers. |

This table shows substantial differences in the overall approach to assessment methods. Whereas the DP prioritises external assessment in the form of exams, the Ontario system relies more heavily on flexible methods of internal assessment. Ontario subjects do use a terminal evaluation that is likely to be an examination in many cases, but this is still internally set and marked.

As the assessment methods in Ontario are intended to assess the learning outcomes in the subject guides, there is a likelihood that there would be substantial alignment with the DP subjects in terms of question types used. However, the level of alignment is hard to conclusively judge due to the high level of flexibility within the Ontario approach to assessment.

As the Ontario subject curriculum assessment is based on flexible internal assessment, comparisons with the question types and other aspects of the assessment structure of the DP are challenging. However, both programmes use clear assessment objectives to demonstrate the nature and proportional importance of the skills assessed. Considering these, therefore, provides valuable insight into the nature of assessment for comparative purposes.

Individual Ontario courses for grades 9-12 use a common achievement chart that draws a link between the mark achieved for the subject (as a percentage) and the skills used. The broad skill categories are:

- Knowledge and Understanding
    - Subject-specific content acquired in each course (knowledge), and the comprehension of its meaning and significance (understanding).
- Thinking and Investigation
    - The use of critical and creative thinking skills and inquiry, research, and problem-solving skills and/or processes.
- Communication
    - The conveying of meaning through various forms.
- Application
    - The use of knowledge and skills to make connections within and between various contexts.

50% is the passing mark for these courses, with the following broad grade categories applying above that level:

- Level 1: 50-59% - *limited* achievement
- Level 2: 60-69% - *some* achievement
- Level 3: 70-79% - *considerable* achievement
- Level 4: 80-100% - a *high degree* or *thorough* achievement.[61]

These skill categories appear to function as assessment objectives. Although they do not receive a specific weighting in the subject curricula, it is stated that ‘Teachers will ensure that student work is assessed and/or evaluated in a balanced manner with respect to the four categories, and that achievement of particular expectations is considered within the

[61] Ibid.

appropriate categories.'[62] This indicates that all four assessment objectives should carry roughly equal weighting (+/- 25% each). Based on this assumption, the following table outlines the comparative weighting of assessment objectives in the DP and the Ontario curricula in the subjects considered within this study.

*Table 14: Comparison of assessment objectives*

| | AO1 | AO2 | AO3 | AO4 | AO5 | AO6 |
|---|---|---|---|---|---|---|
| All Ontario subject curricula | 25% Knowledge and Understanding | 25% Thinking and Investigation | 25% Communication | 25% Application | | |
| DP mathematics: analysis and approaches SL | +/-19% Knowledge and Understanding | +/-20% Problem Solving | +/-21% Communication and Interpretation | +/-15% Technology | +/-10% Reasoning | +/-15% Inquiry Approaches |
| DP mathematics: analysis and approaches HL | +/-17% Knowledge and Understanding | +/-20% Problem Solving | +/-20% Communication and Interpretation | +/-15% Technology | +/-11% Reasoning | +/-16% Inquiry Approaches |
| DP mathematics: applications and interpretation SL | +/-18% Knowledge and Understanding | +/-19% Problem Solving | +/-20% Communication and Interpretation | +/-20% Technology | +/-11% Reasoning | +/-13% Inquiry Approaches |
| DP mathematics: applications and interpretation HL | +/-16% Knowledge and Understanding | +/-19% Problem Solving | +/-20% Communication and Interpretation | +/-19% Technology | +/-11% Reasoning | +/-15% Inquiry Approaches |
| DP sciences SL | +/-25% Knowledge and Understanding | +/-25% Application | +/-45% Formulate, Analyse and Evaluate | +/-5% Investigation Skills | | |
| DP sciences HL | +/-25% Knowledge and Understanding | +/-25% Application | +/-45% Formulate, Analyse and Evaluate | +/-5% Investigation Skills | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | Knowledge and understanding | | Thinking and investigation skills | | Problem solving |
| | Application | | Communication | | Formulate, analyse and evaluate |
| | Technology | | Reasoning | | Inquiry approaches |

As can be seen in the table above, the DP sciences (both SL and HL) and the Ontario subjects all assess knowledge and understanding as roughly one-quarter of the weighting of total assessment. The DP mathematics attribute a slightly lower weighting to knowledge and understanding, with weighting in those subjects spread over a wider range of more specific assessment objectives.

Communication skills are assessed at between roughly one-fifth and one-quarter of total assessment in the Ontario subjects and in DP mathematics. DP sciences do not have an

[62] Government of Ontario, Ministry of Education. (2007). The Ontario Curriculum Grades 11 and 12. p. 25. https://www.edu.gov.on.ca/eng/curriculum/secondary/math1112currb.pdf

individual assessment objective for communication, but it is included as one of the three key skills within the 25% apportioned to application.

Overall, although there is variation in the structure of assessment objectives between Ontario and the DP (and weighting is rarely identical), the key takeaway from comparing these assessment objectives is that similar priorities are placed on a comparable range of skills. With roughly one-fifth to one-quarter of assessment targeting knowledge and understanding, that leaves three-quarters to four-fifths of assessment weighting on application, investigation, problem solving, and communication. This demonstrates that both programmes are recognising the importance of a foundation of knowledge and understanding but are seeking with their assessment to evaluate how students can use, explore, and articulate that understanding. Thus, although there are significant differences in the methods of assessment used in the DP and the Ontario programme, the skills-based criteria for assessment show broad alignment.

# 5. Subject-Level Alignment

This section focuses on answering RQ3 and the sub-questions associated to it, namely:

*Table 15: Research question 3*

| |
|---|
| **RQ3:** To what degree do the subjects align with regards to:<br>3.1: Content<br>• Topics (i.e. scope of content area, breadth depth)<br>• Learning activities (i.e. difficulty, demand).<br>3.2: Expected learning outcomes<br>• Knowledge<br>• Competencies (i.e. subject-specific, 21st century competencies). |

For each subject area, there is a brief introduction to the subjects being compared, followed by an overview of the findings from the comparative analysis between the IB subjects and the OSSD comparison points regarding learning outcomes, content, and demand.

## 5.1 Mathematics

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

**Mathematics: analysis and approaches**[63]
Mathematics: analysis and approaches (AA) 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 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**[64]
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.

[63] International Baccalaureate. (2019). *Mathematics: analysis and approaches guide*.
[64] International Baccalaureate. (2019). *Mathematics: applications and interpretation guide.*

**Grade 9 (De-streamed)**[65]

Grade 9 is the first grade of high school in Ontario and is also the first grade in which a completed course can count as a credit towards the OSSD. Prior to 2021, grade 9 had two streams, 'Academic' and 'Applied', within which were the courses Principles of Mathematics and Foundations of Mathematics, respectively. From 2021, the grade 9 curriculum was de-streamed and now offers one course to be taken by all students and prepares them for all study options in grade 10.

**Grade 10 Principles of Mathematics**[66]

Principles of Mathematics is the course available in Ontario's grade 10 'Academic' stream. This course is suitable for students who are likely to enter the University Preparation stream and prepares students for grade 11 Functions.

**Grade 10 Foundations of Mathematics**[67]

Foundations of Mathematics is the course available in Ontario's grade 10 'Applied' stream. This course is suitable for those who are likely to enter the College Preparation stream and prepares students for grade 11 Functions and Applications.

**Grade 11 Functions**[68]

Grade 11 Functions is the first mathematics course to be taken in Ontario's 'University Preparation' stream. As such, many students who intend to go to university after high school will take this course. This course builds on learning developed in grade 10 Principles of Mathematics course and is designed to prepare students for grade 12 courses.

**Grade 11 Functions and Applications**[69]

Grade 11 Functions and Applications sits within Ontario's 'University/College Preparation' stream and provides preparation for those who intend to study technology-related programmes in college, whilst also leaving an option for students to study grade 12 Mathematics of Data Management (University Preparation). Functions and Applications builds on grade 10 Foundations of Mathematics and introduces functions through an applied approach, with less emphasis on abstract concepts than grade 11 Functions.

**Grade 12 Advanced Functions**[70]

Advanced Functions (AF) is one of three available courses in the Ontario's grade 12 University Preparation stream. Advanced Functions builds on and extends the concepts developed in its prerequisite course, grade 11 Functions. This course is intended to prepare students for university study in areas that include business, social science, and health science programmes.

[65] Government of Ontario, Ministry of Education. (2021). *Mathematics (2021).* https://www.dcp.edu.gov.on.ca/en/curriculum/secondary-mathematics/courses/mth1w
[66] Government of Ontario, Ministry of Education. (2005). *The Ontario Curriculum Grades 9 and 10 Mathematics.* math910curr.pdf (gov.on.ca)
[67] Ibid.
[68] Government of Ontario, Ministry of Education. (2007). *The Ontario Curriculum Grades 11 and 12 Mathematics.*
[69] Ibid.
[70] Ibid.

**Grade 12 Calculus and Vectors**[71]
Calculus and Vectors (CV) can only be studied following, or concurrently with, Advanced Functions and is designed to prepare students for university programmes, such as science, engineering, and economics, that include a calculus or linear algebra course in the first year.

**Grade 12 Mathematics of Data Management**[72]
Mathematics of Data Management (DM) can be accessed with either grade 11 Functions or Functions and Applications and is intended to prepare students for university study in programmes that may include statistical elements, such as those found in the social sciences and the humanities.

### 5.1.1 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 AA and AI. Similarly, Ontario sets out a standard list of seven mathematical process expectations which are applicable to all courses in grades 9-12. In 2021, the grade 9 curriculum was updated to incorporate two further expectations: Strand AA (Social-Emotional Learning [SEL] Skills in Mathematics) and Strand A (Mathematical Thinking and Making Connections). The additional grade 9 learning outcomes will be analysed and discussed separately in this section.

The following table demonstrates the learning outcome themes that were extracted from the DP mathematics curricula and indicates if and where they were judged to have presence within the learning outcomes of the OSSD mathematics curricula.

*Table 16: Presence of the DP mathematics subject group learning outcome themes in Ontario curricula (OSSD)*

| Themes extracted from the learning outcomes in the DP mathematics subject group | Presence in the OSSD's mathematics learning outcomes | |
|---|---|---|
| 1. Being aware of, and engaging with, mathematics in its wider context | | Present in the Mathematical Process of 'Connecting' and in the grade 9 Strand A expectation. |
| 2. Developing learning skills; having a positive and resilient attitude, working both independently and collaboratively, being reflective and evaluating work | | Present in the Mathematical Process of 'Reflecting' and in the grade 9 further expectations on 'Social-Emotional Learning Skills' |
| 3. Using inquiry-based approaches | | Present across three different Mathematical Process expectations (Problem-solving, Reflecting, and Computational Strategies) |

[71] Ibid.
[72] Ibid.

| | | |
|---|---|---|
| 4. Understanding the concepts, principles and nature of mathematics and applying concepts and procedures to a range of contexts | | Generally present in the Mathematical Process expectations and in the grade 9 further expectations. |
| 5. Making links and generalisations | | Present in two expectations ('Connecting' and 'Representing') and in the grade 9 Strand A expectation |
| 6. Developing critical/creative thinking skills e.g. problem-solving and reasoning | | Present across a wide range of the Process outcomes and the grade 9 further expectations. |
| 7. Communicating mathematics clearly and in various forms | | Present across three different Process outcomes. |
| 8. Knowing how technology and mathematics influence each other and using technology to develop ideas and solve problems | | Present in two process expectations ('Selecting Tools and Computational Strategies' and 'Representing'). |

Key:

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

*Presence of the DP's Learning Outcome Themes*

As demonstrated in the table above, there is strong alignment with the DP mathematics learning outcome themes in Ontario's 'Mathematical Process Expectations' for grades 9-12, with the latter also reflecting an emphasis on the development of conceptual understanding and higher-level thinking skills.

Firstly, the theme of critical-thinking development is clearly present, as problem-solving and reasoning are identified separately as two of the seven processes and are embedded into others relating to technology, representations, and reflection. Also embedded in the OSSD learning outcomes is the theme of inquiry approaches, as the expectations make frequent references to working within the context of an investigation. Similarly, the OSSD Mathematical Process Expectations have a technology theme and expect that students use appropriate tools, not only for calculations and representations, but also to problem-solve and investigate ideas. There is further alignment with the DP themes, as the expectations include that students will be able to apply understanding to a range of contexts, communicate mathematics effectively in various ways, and reflect critically on their work.

Although there are many similarities, there are some differences within the themes. For example, though there is evidence that Ontario requires students to engage with mathematics in a wider context in 'Connections', this appears to mostly involve links to other disciplines and daily life, thus is not as extensive as the DP in considering global and historic perceptions and

thinking critically about the implications of mathematics. Furthermore, although the Mathematical Process Expectations concentrate on developing some learning skills, such as critically reflective practice, they do not explicitly include outcomes directed at collaboration or students' disposition towards the study of mathematics. However, although these elements are less present, they are mentioned in the extended description of 'Problem-solving', where 'building confidence' and 'promoting collaborative sharing' are listed as benefits.

*Presence of DP Themes - Grade 9 Only*

In 2021, Ontario de-streamed grade 9 (to no longer differentiate between academic and applied), which brought some changes to the curriculum. Here, two more expectations were added, in addition to the Mathematical Process Expectations also used in grades 10-12. Therefore, grade 9 expectations contain all the similarities mentioned above, with further considerations needed for the additional expectations introduced. The first addition is the expectation that students develop 'Social-Emotional Learning (SEL) Skills', which include developing healthy relationships (collaboration), identifying emotions that support mathematical learning (attitudes), and building perseverance. This expectation has strong alignment with the DP.

The other addition is that of 'Mathematical Thinking and Making Connections', which is split into two parts, the first referring to the development of conceptual understanding through the application of the Mathematical Processes and the second describing making connections to knowledge systems, lived experiences, and real-world applications. Hence, the inclusion of this expectation links to the DP's theme of awareness and engagement with maths in its wider context. This makes the global perspectives theme more present in grade 9 in the OSSD compared to later grades, as it includes attention to knowledge systems. Therefore, with these additions, alignment with the DP is stronger in grade 9's expectations than in the other grades (and some of the aforementioned differences are minimalised).

*Other Themes in the OSSD*

For Ontario grades 10-12, there is no significant theme in their learning outcomes that is not present in the DP, though a general theme of 'Connecting' is focused on more strongly, as it is one of the seven Processes and embedded throughout. Indeed, like the DP, the 'Connecting' outcome intends students to make links to other disciplines, but also goes further to expect that links are also made between different mathematical topics and amongst mathematical concepts and procedures. Furthermore, in 'Representing', students are expected to be able to create a variety of representations of mathematical ideas, in order to see the connections between them and develop their mathematical learning and understanding. Therefore, by having these outcomes, Ontario perhaps focuses more on connections made within mathematics and the development of flexible thinking about mathematical concepts, whereas the DP outcomes place more emphasis on thinking about mathematics in a wider interdisciplinary and global context.

*Other Themes - Grade 9 Only*

In grade 9 specifically, the outcome that is the most different to the DP's is that of expecting students to develop 'Social-Emotional Learning (SEL) Skills' during their mathematics studies. There is some overlap here with the DP's theme of developing learning skills, including a positive disposition, patience, collaboration, and critical and creative thinking. However, the SEL skills go beyond these to involve:

- 'recognizing and identifying emotions that support mathematical learning;
- recognizing sources of stress that present challenges to mathematical learning;
- identifying resources and supports that aid perseverance in mathematical learning;
- building healthy relationships and communicating effectively in mathematics;
- developing a healthy mathematical identity through building self-awareness;
- developing critical and creative mathematical thinking'.[73]

Therefore, the OSSD learning outcomes in grade 9 focus on developing students' self-awareness and self-regulation to a greater extent than the DP's learning outcomes overall. Moreover, these skills are more comprehensive with regards to expecting students to think about their mathematical learning and thus more obviously promote metacognition skills, which are present but not as strongly reflected in DP's learning outcomes for mathematics.

*Summary*
Overall, there is considerable alignment between the learning outcomes of the DP's mathematics subjects and Ontario's. Differences, where found, are generally at the level of emphasis rather than being substantial differences related to the absence and presence of important skills. The new grade 9 learning outcomes in Ontario bring the overall alignment closer than before these were updated, suggesting that the two systems may even further converge at the learning outcomes level when the OSSD curricula are further updated in the following grades.

### 5.1.2 Content – Mathematics

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

[73] Government of Ontario, Ministry of Education. (2021). *Grade 9 Maths Expectations by Strand*. Mathematics (2021) (gov.on.ca)

*Figure 8: 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 and geometric sequences and series; 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 9: 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 10: Ontario mathematics grades 9 and 10 content visualiser*

| | | | | | |
|---|---|---|---|---|---|
| **Grade 9 De-streamed** | **AA. Social-Emotional Learning (SEL) Skills in Mathematics** | AA1. Social-Emotional Learning Skills | | | |
| | **A. Mathematical Thinking and Making Connections** | A1. Mathematical Processes | A2. Making Connections | | |
| | **B. Number** | B1. Development of Numbers and Number Sets | B2. Powers | B3. Number Sense and Operations | |
| | **C. Algebra** | C1. Algebraic Expressions and Equations | C2. Coding | C3. Application of Relations | C4. Characteristics of Relations |
| | **D. Data** | D1. Collection, Representation, and Analysis of Data | D2. Mathematical Modelling | | |
| | **E. Geometry and Measurement** | E1. Geometric and Measurement Relationships | | | |
| | **F. Financial Literacy** | F1. Financial Decisions | | | |
| **Grade 10 Foundations of Mathematics** | **1. Measurement and Trigonometry** | a. Solving Problems Involving Similar Triangles | b. Solving Problems Involving the Trigonometry of Right Triangles | c. Solving Problems Involving Surface Area and Volume, Using the Imperial and Metric Systems of Measurement | |
| | **2. Modelling Linear Relations** | a. Manipulating and Solving Algebraic Equations | b. Graphing and Writing Equations of Lines | c. Solving and Interpreting Systems of Linear Equations | |
| | **3. Quadratic Relations of the Form $y = ax^2 + bx + c$** | a. Manipulating Quadratic Expressions | b. Identifying Characteristics of Quadratic Relations | c. Solving Problems by Interpreting Graphs of Quadratic Relations | |
| **Grade 10 Principles of Mathematics** | **1. Quadratic Relations of the Form $y = ax^2 + bx + c$** | a. Investigating the Basic Properties of Quadratic Relations | b. Relating the Graph of $y = x^2$ and Its Transformations | c. Solving Quadratic Equations | d. Solving Problems Involving Quadratic Relations |
| | **2. Analytic Geometry** | a. Using Linear Systems to Solve Problems | b. Solving Problems Involving Properties of Line Segments | c. Using Analytic Geometry to Verify Geometric Properties | |
| | **3. Trigonometry** | a. Investigating Similarity and Solving Problems Involving Similar Triangles | b. Solving Problems Involving the Trigonometry of Right Triangles | c. Solving Problems Involving the Trigonometry of Acute Triangles | |

*Figure 11: Ontario mathematics grades 11 and 12 content visualiser*

| | | | | | |
|---|---|---|---|---|---|
| **Grade 11 Functions** | **A. CHARACTERISTICS OF FUNCTIONS**<br>1. Representing Functions<br>2. Solving Problems Involving Quadratic Functions<br>3. Determining Equivalent Algebraic Expressions* | **B. EXPONENTIAL FUNCTIONS**<br>1. Representing Exponential Functions<br>2. Connecting Graphs and Equations of Exponential Functions<br>3. Solving Problems Involving Exponential Functions | **C. DISCRETE FUNCTIONS**<br>1. Representing Sequences<br>2. Investigating Arithmetic and Geometric Sequences and Series<br>3. Solving Problems Involving Financial Applications | **D. TRIGONOMETRIC FUNCTIONS**<br>1. Determining and Applying Trigonometric Ratios<br>2. Connecting Graphs and Equations of Sinusoidal Functions<br>3. Solving Problems Involving Sinusoidal Functions | |
| **Grade 11 Functions and Applications** | **A. QUADRATIC FUNCTIONS**<br>1. Solving Quadratic Equations<br>2. Connecting Graphs and Equations of Quadratic Functions<br>3. Solving Problems Involving Quadratic Functions | **B. EXPONENTIAL FUNCTIONS**<br>1. Connecting Graphs and Equations of Exponential Functions<br>2. Solving Problems Involving Exponential Functions<br>3. Solving Financial Problems Involving Exponential Functions | **C. TRIGONOMETRIC**<br>1. Applying the Sine Law and the Cosine Law in Acute Triangles<br>2. Connecting Graphs and Equations of Sine Functions<br>3. Solving Problems Involving Sine Functions | | |
| **Grade 12 Advanced Functions** | **A. EXPONENTIAL AND LOGARITHMIC FUNCTIONS**<br>1. Evaluating Logarithmic Expressions<br>2. Connecting Graphs and Equations of Logarithmic Functions<br>3. Solving Exponential and Logarithmic Equations | **B. TRIGONOMETRIC FUNCTIONS**<br>1. Understanding and Applying Radian Measure<br>2. Connecting Graphs and Equations of Trigonometric Functions<br>3. Solving Trigonometric Equations | **C. POLYNOMIAL AND RATIONAL FUNCTIONS**<br>1. Connecting Graphs and Equations of Polynomial Functions<br>2. Connecting Graphs and Equations of Rational Functions<br>3. Solving Polynomial and Rational Equations<br>4. Solving Inequalities | **D. CHARACTERISTICS OF FUNCTIONS**<br>1. Understanding Rates of Change<br>2. Combining Functions<br>3. Using Function Models to Solve Problems | |
| **Grade 12 Calculus and Vectors** | **A. RATE OF CHANGE**<br>1. Investigating Instantaneous Rate of Change at a Point<br>2. Investigating the Concept of the Derivative Function<br>3. Investigating the Properties of Derivatives | **B. DERIVATIVES AND THEIR APPLICATIONS**<br>1. Connecting Graphs and Equations of Functions and Their Derivatives<br>2. Solving Problems Using Mathematical Models and Derivatives | **C. GEOMETRY AND ALGEBRA OF VECTORS**<br>1. Representing Vectors Geometrically and Algebraically<br>2. Operating with Vectors<br>3. Describing Lines and Planes Using Linear Equations<br>4. Describing Lines and Planes Using Scalar, Vector, and Parametric Equations | | |
| **Grade 12 Mathematics of Data Management** | **A. COUNTING AND PROBABILITY**<br>1. Solving Probability Problems Involving Discrete Sample Spaces<br>2. Solving Problems Using Counting Principles | **B. PROBABILITY DISTRIBUTIONS**<br>1. Understanding Probability Distributions for Discrete Random Variables<br>2. Understanding Probability Distributions for Continuous Random Variables | **C. ORGANIZATION OF DATA FOR ANALYSIS**<br>1. Understanding Data Concepts<br>2. Collecting and Organizing Data | **D. STATISTICAL ANALYSIS**<br>1. Analysing One-Variable Data<br>2. Analysing Two-Variable Data<br>3. Evaluating Validity | **E. CULMINATING DATA MANAGEMENT INVESTIGATION**<br>1. Designing and Carrying Out a Culminating Investigation<br>2. Presenting and Critiquing the Culminating Investigation |

*Structure*

For students to graduate secondary school with an OSSD, they must achieve a minimum of three mathematics credits, with at least one credit in grade 11 or 12. Thus, the mathematics programme for the OSSD spans three-four years, compared to the DP's two years. Similarly, both programmes require students to continue studying mathematics during the last two years of secondary education, for the OSSD this is a minimum of 110 hours in either grade 11 or 12 (for one credit) and for DP students this is a minimum of 150 hours (for SL).

Furthermore, like the DP, Ontario offers courses designed for different students' future education and careers. Indeed, mathematics content in both programmes is differentiated with regards to where emphasis is placed (pure versus applied). For the DP, this is in the form of AA and AI subjects and for the OSSD this is the offering of Academic or Applied courses in grade 10 and University or College Preparation courses from grade 11. Applied and College Preparation courses' content explore maths with a stronger focus on practical applications. However, where both DP subjects' content prepares students for university programmes, in the OSSD students need to take University Preparation courses. All students in this stream take grade 11 Functions and then have a choice of grade 12 courses.

From grade 11 onwards, there are differences in the structure of content between the mathematics subjects in the DP and the OSSD University Preparation (UP) stream. The UP courses available do not separate topic content into levels, such as the DP's SL and HL, nor do they integrate a range of main topics, instead each course tends to focus on a specific area of mathematics. For instance, calculus is studied in all DP mathematics subjects, whereas in the UP stream it is studied only within the grade 12 Calculus and Vectors course. Therefore, the variable in the UP courses' mathematics content is the number of main topics which are studied, whereas for the DP it is the amount of content within each main topic.

*Content Alignment*

From here onwards, the analysis will focus on grades 11 and 12. Although grades 9 and 10 are part of the programme, the content and demand of these grades is typical of learning *prior* to upper secondary mathematics. Therefore, for meaningful comparison to the upper secondary DP, it is logical to direct attention to the last two grades of secondary education in Ontario.

To complement the analysis, the figures below represent a simplified summary of the OSSD's content alignment, at topic-level, with AA (SL and HL) and AI (SL and HL).[74]

[74] The content of grades 9 and 10 was also mapped but is not represented in the table. Very little alignment was found with these grades due to their content being more typical of prior learning to upper secondary mathematics.

*Figure 12: Summary of the content alignment OSSD has with the main topics in AA*

| | | Presence in OSSD | | | | | |
|---|---|---|---|---|---|---|---|
| **Mathematics: analysis and approaches topics** | | **Grade 11 Functions and applications** | **Grade 11 Functions** | **Grade 12 Advanced Functions** | **Grade 12 Calculus and Vectors** | **Grade 12 Data Management** | **University Preparation (combined)** |
| SL | 1. Number and algebra | | | | | | |
| | 2. Functions | | | | | | |
| | 3. Geometry and trigonometry | | | | | | |
| | 4. Statistics and probability | | | | | | |
| | 5. Calculus | | | | | | |
| AHL | 1. Number and algebra | | | | | | |
| | 2. Functions | | | | | | |
| | 3. Geometry and trigonometry | | | | | | |
| | 4. Statistics and probability | | | | | | |
| | 5. Calculus | | | | | | |

*Figure 13: Summary of the content alignment the OSSD has with the main topics in AI*

| | | Presence in OSSD | | | | | |
|---|---|---|---|---|---|---|---|
| **Mathematics: applications and interpretation topics** | | **Grade 11 Functions and applications** | **Grade 11 Functions** | **Grade 12 Advanced Functions** | **Grade 12 Calculus and Vectors** | **Grade 12 Data Management** | **All University Preparation** |
| SL | 1. Number and algebra | | | | | | |
| | 2. Functions | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3. Geometry and trigonometry | | | | | | |
| | 4. Statistics and probability | | | | | | |
| | 5. Calculus | | | | | | |
| AHL | 1. Number and algebra | | | | | | |
| | 2. Functions | | | | | | |
| | 3. Geometry and trigonometry | | | | | | |
| | 4. Statistics and probability | | | | | | |
| | 5. Calculus | | | | | | |

Key:

| | | | | | |
|---|---|---|---|---|---|
| | *Strong presence of this topic in the OSSD* | | *Partial presence of this topic in the OSSD* | | *Little or no presence of this topic in the OSSD* |

* Where applicable, content alignments found in pre-requisite subjects are carried forwards and combined with new alignments to represent the cumulative content covered.

## ***Grade 11***

*Mathematics: analysis and approaches*

Courses offered in grade 11 are 'Functions' (University Preparation) and 'Functions and Applications' (College Preparation). There are more instances of alignment with AA in 'Functions' content than in 'Functions and Applications', though not a significant amount in most topics.

In grade 11, functions are introduced in both courses and each cover quadratic, exponential, and trigonometric functions. Therefore, there are strong and partial alignments with 'Functions' sub-topics in AA SL. Indeed, the topic of 'Functions' is the topic that the OSSD has the most alignment with for grade 11 content. However, OSSD Functions and OSSD Functions and Applications further include sub-topics which involve the modelling of these functions, which is not a focus for AA. Both courses also have a similar number of alignments with AA SL at sub-topic level in the topic 'Geometry and trigonometry' – though fewer than those found with 'Functions'. No 'Geometry and trigonometry' AHL content areas are covered in OSSD grade 11, nor are some SL sub-topics such as solving trigonometric equations and introducing radians.

The alignment difference to AA between 'Functions' and 'Functions and Applications' is most obvious in 'Number and algebra', which is due to grade 11 Functions containing an area

dedicated to 'Discrete Functions', which is not in Functions and Applications. This area explores sequences and the binomial theorem, hence there are alignments with these sub-topics in AA, along with evidence of simple proof (SL) from other topics. Hence, grade 11 Functions covers most SL sub-topics in AA 'Number and algebra', but no AHL sub-topics. With regards to other topics, no 'Calculus' is covered by the end of OSSD grade 11, and no further statistics or probability content is covered.

Overall, grade 11 content aligns with a good amount of AA SL content in 'Number and algebra', 'Functions', and 'Geometry and trigonometry', minimal amounts of SL content in 'Statistics and probability', and no content from 'Calculus'. OSSD grade 11 Functions and Applications is similar but has less content shared with 'Number and algebra'. There is no alignment with AHL content. There are few areas which are covered in grade 11 that are not covered by AA. Where these do exist, they relate to aspects of modelling and some further financial applications, such as annuities.

*Mathematics: applications and interpretation*

As with AA, the AI topic that grade 11 content has the most sub-topic alignments with is 'Functions'. Like AI, OSSD Functions and OSSD Functions and Applications place importance on modelling with functions and using modelling processes, thus there is strong alignment in this topic – however, these courses do not model with as many functions as AI. There are less instances of alignment in AI 'Number and algebra', though grade 11 Functions has more alignment than Functions and Applications due to including sequences and their financial applications as part of its 'Discrete Functions' section. Grade 11 Functions and Applications also considers financial applications, though within the context of exponential functions rather than sequences. There are limited examples of alignment with 'Geometry and trigonometry', with most coming from the more basic sub-topics in this area. There is no further 'Statistics and probability' content covered in OSSD grade 11 to extend content covered in grade 9, and calculus is not studied until grade 12.

Overall, grade 11 Functions has alignment with most SL content in 'Functions', plus parts of AHL; a good amount of SL content in 'Number and algebra'; some SL content in 'Geometry and trigonometry'; minimal SL content in 'Statistics and probability'; and no content in 'Calculus'. The same applies for Functions and Applications, with the difference being coverage of fewer 'Number and algebra' areas and some small aspects of functions and trigonometry not being included either. There is no alignment with AHL content.

*Table 17: OSSD grade 11 content which is not covered by DP mathematics subjects*

| Significant grade 11 content not in AA (only) | Significant grade 11 content not in AI (only) |
|---|---|
| • A focus on modelling with functions e.g. sinusoidal models<br>• Some financial applications (annuities) | |
| **Significant content not in either DP mathematics subject *** | |
| N/A | |

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

***Grade 12***

This section considers OSSD content alignment with AA and AI if all University Preparation courses are taken in grade 12 (i.e. Advanced Functions, Calculus and Vectors, and Data Management). However, it is important to note that, to achieve the OSSD, it is not necessary that students take all (or in fact any) grade 12 University Preparation courses. That said, it is likely that those going to university will need Calculus and Vectors (and, by default, Advanced Functions), with some also recommending that Data Management be taken. The relevant alignments from pre-requisites (such as grade 11 Functions) will also be taken into account, to create a picture of all the content covered from grades 9-12. Following this subsection, there will be consideration of how alignment is affected in the cases where certain grade 12 courses are not taken.

*Mathematics: analysis and approaches*

The University Preparation courses' content has sub-topic alignments with all topics in AA, to varying degrees. The topic that UP has the strongest alignment with is that of 'Functions', due to the OSSD offering two courses focusing on this area of mathematics – grade 11 Functions and grade 12 Advanced Functions. Grade 12 builds on grade 11 to include rational, polynomial, logarithmic, and composite functions. However, not all AHL 'Functions' content is covered, Advanced Functions instead focuses on modelling and solving real-world problems with some of these functions.

After 'Functions', the next topic UP courses have the most alignments with is 'Geometry and trigonometry', as they have partial or strong alignment with nearly every SL and AHL sub-topic. Similarly, UP courses combined include 'Geometry and trigonometry' concepts such as solving trigonometric equations, vectors, trigonometric identities, reciprocal trigonometric functions, and radians.

For 'Number and algebra', the UP courses have very strong alignment with SL content, though only minimal instances of alignments are with AHL content; indeed, none of the UP courses included complex numbers or proof by contradiction/induction. Many of the sub-topics in SL 'Statistics and probability' are present in UP courses, with Data Management covering some SL sub-topics such as correlation and regression, introducing probability and set notation, and looking at several probability distributions – including different ones such as hypergeometric. Similar to both DP subjects, an investigation is conducted in Data Management which involves students choosing an area, carrying out an investigation, reporting and presenting their findings, and critically reviewing theirs and others' work.

For 'Calculus', UP courses have good alignment with SL content, except for sub-topics related to the area of integration – UP courses only cover differentiation. Furthermore, apart from understanding concepts of limits and first principles, no other AHL content is covered from 'Calculus'; indeed, the UP courses do not cover integrals, methods of integration, further derivatives, implicit differentiation, first order differential equations or Maclaurin series. However, it can be noted that a large amount of their calculus content is focused on investigating the graphs of functions and their derivatives, verifying differentiation rules, and using first principles, thus UP courses do give conceptual depth to the parts of calculus which they do include.

In summary, UP courses combined have strong alignment with all SL topics – except 'Calculus' – strong alignment with AHL 'Geometry and trigonometry', and partial alignment with 'Functions' AHL content. Overall, the UP courses' content is less broad than that of AA AHL, though is larger than SL to some extent. The only significant UP area less present in AA is that of modelling with functions.

*Mathematics: applications and interpretation*

The UP courses' content has sub-topic alignments with all topics in AI – to varying degrees. As with AA, the topic that the UP courses are the most strongly aligned with is 'Functions'. Courses which involve functions in the OSSD specify modelling with a range of functions, identifying key features of graphs, transformations of a variety of functions, and finding composite and inverse functions. Thus, all SL topics are present, with also two out of four AHL topics (some harder models are not covered). However, it can be noted that Advanced Functions include exploration of functions beyond the scope of AI, such as rational and polynomial, and include a heavier focus on analytical solutions.

For AI 'Geometry and trigonometry', UP courses have a mixture of SL and AHL alignments. Most significantly, vectors are covered, as are radians and trigonometric ratios and identities. Advanced Functions goes beyond the scope of AI in this topic by including equations of vector planes, reciprocal trigonometric functions, further identities, and analytically solving trigonometric equations. However, no sub-topics related to Voronoi diagrams, matrices, graph theory, or decision mathematics are present in the UP courses.

For AI 'Statistics and probability', UP courses have strong alignment with most SL sub-topics – presenting data, correlation, probability, and probability distributions – though there are no clear alignments with AHL content such as hypothesis testing, non-linear regression, or Markov Chains. For 'Calculus', UP courses have a mixture of SL and AHL sub-topic alignments, including second derivatives, optimisation, and kinematic problems. However, the area of integration is not covered by any UP courses, hence a considerable number of sub-topics have no alignment. Furthermore, harder topics such as differential equations and phase portraits are also not included. That said, the Calculus and Vectors course gives conceptual depth by exploring graphical representation of derivatives of functions, verifying rules graphically, and looking in detail into first principles.

For AI 'Number and algebra', UP courses have strong alignment with most SL sub-topics and the two AHL sub-topics involving the laws of logarithms and exponentials, however UP courses do not cover complex numbers, matrices, or eigenvalues and eigenvectors.

Overall, content in UP courses is not strongly aligned with AI AHL content – though some topics have a few AHL sub-topics present – but is better aligned with SL topics. Thus, the subject content covered in OSSD is not as broad as HL, but is broader than SL.

*Table 18: OSSD University Preparation content which is not covered by DP mathematics subjects*

| Significant UP content not in AA (only) | Significant UP content not in AI (only) |
|---|---|
| • A focus on modelling with some functions<br>• Some financial applications (e.g. annuities) | • Certain functions e.g. rational functions and polynomials<br>• Reciprocal ratios<br>• Further trigonometric identities<br>• Differentiation from First Principles<br>• Solving inequalities<br>• Solving equations, both graphically and analytically.<br>• Counting principles<br>• Vectors – equations of planes |
| **Significant content not in either DP mathematics subject *** | |
| • Hypergeometric probability distribution | |

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

The section below will look at how alignment is affected in different scenarios where a certain grade 12 University Preparation course is not studied. Since the only mathematics requirement is one credit in either grade 11 or 12, it is likely that pathways such as these will be taken.

**How alignment with the DP is affected when all University Preparation courses are studied except each of the following:**

*(i) Mathematics of Data Management (DM)*

Generally, DM is not a pre-requisite of many university programmes outside of those with a strong statistical element, though there is evidence that it is recommended for STEM courses. If DM is not taken, then students in the University Preparation stream do not encounter any statistics and probability topics after grade 9. Thus, without this course content, there is very minimal alignment with the topic of 'Statistics and probability' in both AA and AI. The alignment with other topics remains the same.

*(ii) Calculus and Vectors*

Calculus and Vectors can only be taken with or after Advanced Functions and is considered to be the highest-level course that can be taken in OSSD mathematics. Often this course is a requirement of university programmes, especially if the course has a STEM element. If the course is not taken, the level of alignment is significantly affected in two main topics for both AA and AI. In 'Geometry and trigonometry', only the alignment with AHL would be affected, due to vectors being no longer covered. In 'Calculus', there would be no alignment with either SL or AHL content for both AA and AI, as this topic is not studied in any other course.

*(iii) Advanced Functions*

If a student does not study Advanced Functions, they cannot study Calculus and Vectors. Thus, the effects on alignment mentioned in the section above would also apply again in this case. Without Advanced Functions, alignment with both AA and AI topics of 'Functions' and 'Geometry and trigonometry' would decrease further – though more significantly for AA. Advanced Functions includes logarithmic, rational, and polynomial functions, meaning that

these alignments with AA would be lost. Composite functions are also introduced in Advanced Functions; thus, not studying the course would affect alignment with both AA and AI. For 'Geometry and trigonometry', there would be fewer alignments with AA due to Advanced Functions including reciprocal trigonometric ratios, radians, further identities and solving trigonometric equations. Some alignment would also be lost with the AI AHL sub-topic of radians.

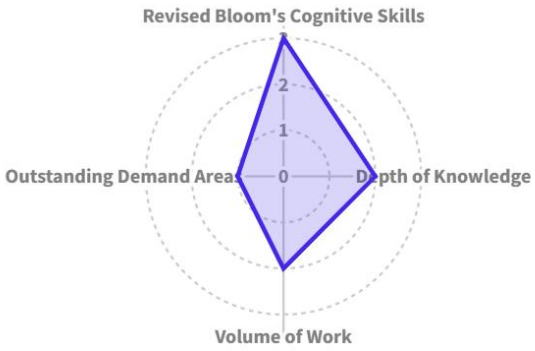
### 5.1.3 Demand – Mathematics

This section considers the alignment between the DP mathematics curricula and mathematics in Ontario in terms of demand.

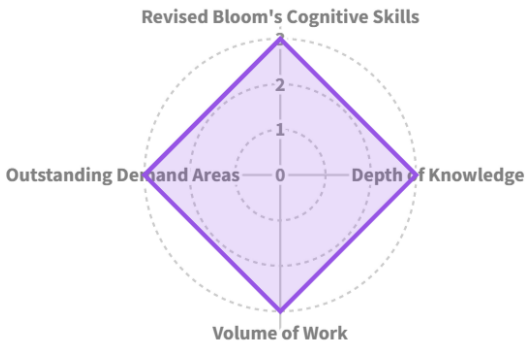
The DP and OSSD curricula were analysed using the same demand tool in order to create a demand profile for AA (SL and HL), AI (SL and HL), OSSD grade 11 Functions and Applications, OSSD grade 11 Functions, OSSD grade 12 Advanced Functions, OSSD grade 12 Calculus and Vectors, OSSD grade 12 Mathematics of Data Management, and OSSD University Preparation (all University Preparation courses in mathematics combined). These demand profiles are presented below in the form of radar diagrams, with the last two diagrams showing the DP subjects and OSSD University Preparation profiles superimposed in one place, enabling immediate visual comparison.

*Figure 14: Visual representations of subject demand*

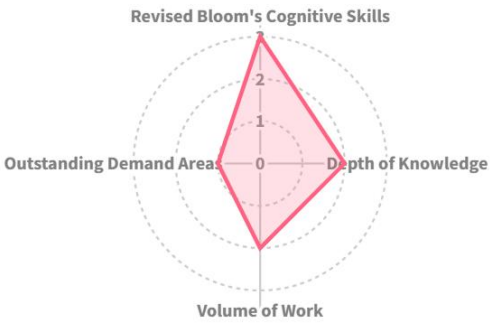
**DP mathematics: analysis and approaches SL**



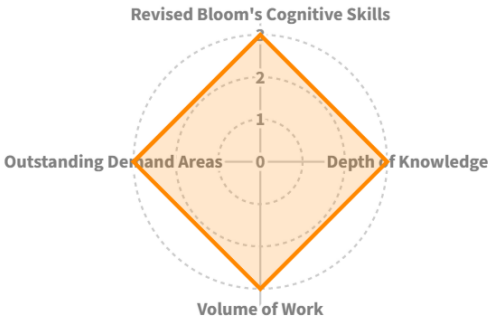

**DP mathematics: analysis and approaches HL**



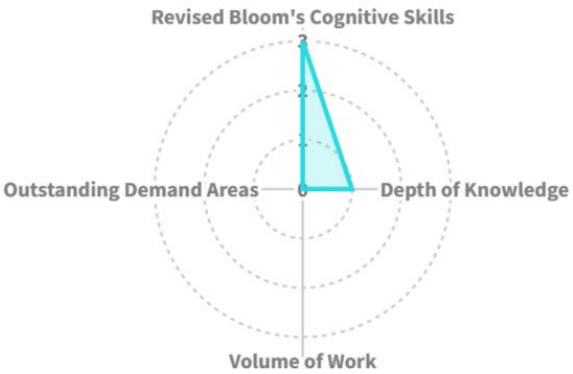

**DP mathematics: applications and interpretation SL**



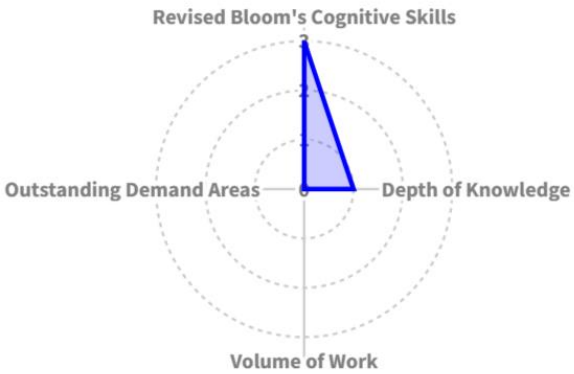

**DP mathematics: applications and interpretation HL**



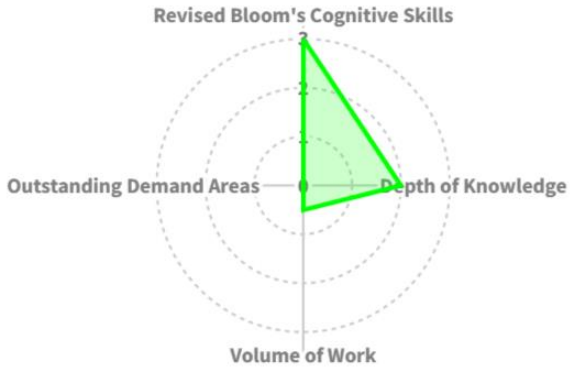

**OSSD Grade 11 Functions and Applications**



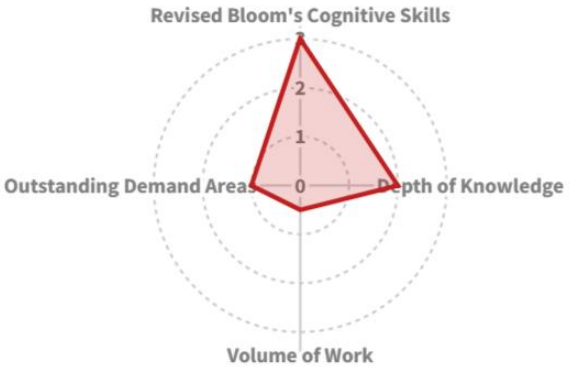

**OSSD Grade 11 Functions**



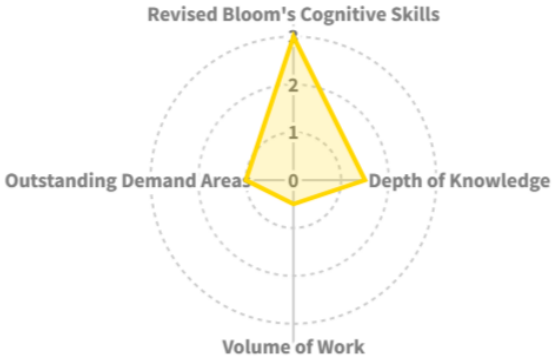
**OSSD Grade 12 Advanced Functions**



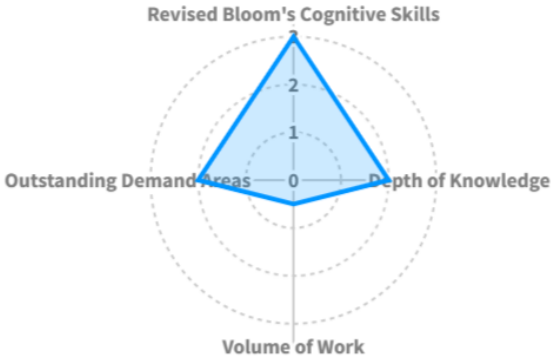

**OSSD Grade 12 Calculus and Vectors**



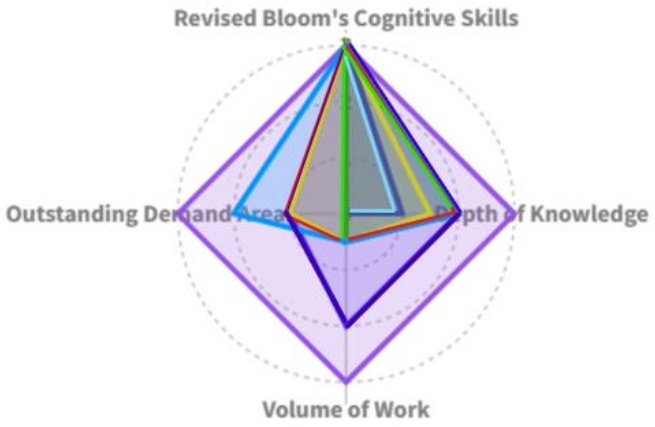

**OSSD Grade 12 Mathematics of Data Management**



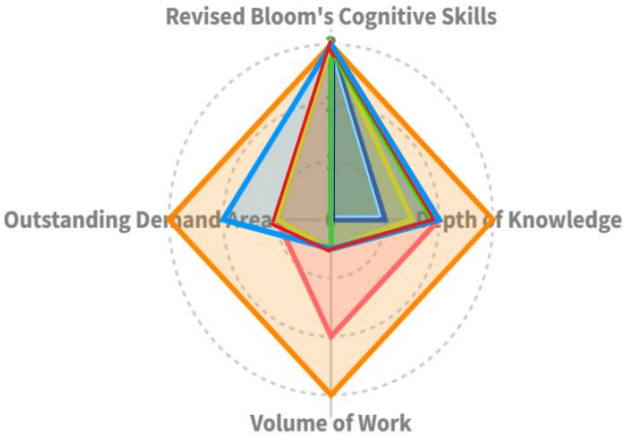

**OSSD University Preparation (all)**




**DP AA SL/HL and OSSD**




**DP AI SL/HL and OSSD**



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**:
  - The DP mathematics subject group learning outcomes apply to all subjects hence the scores are the same for AA (SL and HL) and AI (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.
  - Similarly, the OSSD learning outcomes applied to all courses and thus each has the same score. Like the DP, the OSSD learning outcomes were given a score of 3, which was on the basis that elements of evaluation, creation and analysis were woven into most of their outcomes through references to posing problems, reflecting, investigating, generalising, assessing, and justifying.

- Regarding the scores for **Depth of Knowledge**:
  - Both DP mathematics subjects at SL were given a score of 2. 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.
  - Turning to the OSSD, grade 11 courses had some detail in the topics of Functions and Trigonometry, however the restricted range of functions introduced, and the generally small number of sub-topics covered, meant complexity was limited and was not on par with DP SL, hence a score of 1 was deemed appropriate for both courses. Grade 12 Advanced Functions extended the knowledge from grade 11 Functions to include more complex functions and concepts, hence the higher level of complexity and requirement of considerable pre-requisite knowledge warranted a score of 2. Furthermore, grade 12 Calculus and Vectors required considerable pre-requisite knowledge and covered the topic of vectors in high detail – though grasping the foundations of differentiation was given greater precedence than including integration and building complexity, hence an overall score of 2 was awarded. For grade 12 Data Management, a limited amount of pre-requisite information was needed, though the course contained a good amount of analysis and level of detail, thus an overall score of 1.5 was deemed fair for Depth of Knowledge. Finally, the Depth of Knowledge score was considered in the case where all grade 12 University Preparation courses were studied, for which it judged that most topics were typically studied in considerable, rather than a high, level of detail, thus a score of 2 was awarded.

- 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 was 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 merited a score of 3.
  - For the OSSD, courses in grade 11 had a generous amount of time to cover mostly basic concepts, hence the volume of work was low and a score of 0 was given to all. A good comparison which demonstrated this was grade 11 Functions, which had 110 teaching hours to cover a small range of functions and a few sub-topics from other areas, whereas the DP allocated considerably fewer hours (21-31) for Functions at SL. Furthermore, grade 12 Advanced Functions, Calculus and Vectors, and Data Management also each had 110 hours to cover a small number of topics. A score of 0.5 was deemed suitable here as the content was more complex than lower grades but was still too generous to be considered a standard amount of time to justify a score of 1. As another comparison, to study a broad range of topics in considerable detail in the OSSD would require 440 teaching hours (for grade 11 Functions and all grade 12 courses), whereas the DP has 150 hours to cover a similar number of themes and concepts, or 240 hours to cover all topics in further detail than the OSSD. Overall, the volume of work in mathematics was a significant difference between the OSSD and the DP.

- Regarding the scores for **Outstanding Areas of Subject Demand**:
  - Both DP mathematics subjects at SL and contained one area of demand, which was 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 had further areas of outstanding demand. For mathematics: analysis and approaches, some of the identified outstanding areas of demand were 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 was a high number of outstanding areas of demand and a score of 3 was awarded to both HL subjects.
  - For Ontario, no areas of outstanding demand were found in grade 11, nor were any identified in grade 12 Advanced Functions. These courses included content that was either typical of upper secondary mathematics or below, thus each was awarded a score of 0 for this category. Calculus and Vectors was agreed to merit a score of 1 due to identified areas of outstanding demand within vector sub-topics (C3 Describing lines and planes using linear equations and C4 Describing lines and planes using scalar, vector, and parametric equations). Data Management was

also awarded a score of 1 for its 'Culminating Investigation' which required students to collect, model and analyse data, apply ethical practices, consider bias, produce a report, present findings to peers, respond to questioning, and offer own critiques. Finally, in the scenario where all grade 12 courses are taken, the scores for Outstanding Areas of Demand would be combined from Calculus and Vectors and Data Management to give a total score of 2.

## 5.2 Physics

Below is the list of subjects used in the physics subject comparison analysis of the DP with the OSSD.

**DP physics**[75]
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

**OSSD grades 9 and 10 science: Academic**[76]
Grades 9 and 10 are split into two streams, Academic and Applied. For the purposes of this report, the Academic stream and following courses will be the focus. The different areas of science are integrated at this grade to include concepts in chemistry, biology, physics, and earth and space science. The academic stream develops students' skills through the study of theory and abstract problems, whereas the applied stream emphasises practical applications. Students need to study the grade 10 Academic course to be able to access University Preparation physics courses.

**OSSD grades 11 and 12 physics: University Preparation**[77]
Grades 11 and 12 offer University Preparation, University/College Preparation, College Preparation, and Workplace courses. For the purposes of this report, the courses offered in University Preparation will be the focus. Physics is offered as a course from grade 11 and can be continued on to grade 12. These courses will prepare students for further study and are intended to satisfy university science programme requirements. The University Preparation science courses are designated as 'full course options' with 110 hours per academic year.

### 5.2.1 Learning Outcomes – Physics

This section compares and contrasts the learning outcomes of curricula falling within the category of physics.

[75] International Baccalaureate. (2023). *Physics guide*.
[76] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 9 and 10 Science*. The Ontario Curriculum, Grades 9 and 10: Science, 2008 (revised) (gov.on.ca)
[77] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 11 and 12 Science*. https://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf, page 182.

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. Similarly, the OSSD sets out three goals which are the same for all science courses. These goals inform the three overall expectations found in each strand of a course; they also underlie assessment of student achievement. The OSSD goals are the following:

- Goal 1. To relate science to technology, society, and the environment.
- Goal 2. To develop the skills, strategies, and habits of mind required for scientific investigation.
- Goal 3. To understand the basic concepts of science.

Each of the goals above had descriptions which were used for the analysis. Goal 2 was elaborated on in the section ‘Developing Skills of Investigation and Communication’, thus these details were also used.

The following table demonstrates the learning outcome themes that were extracted from the DP learning outcomes and indicates if and where they were judged to have presence within the learning outcomes of the OSSD physics curricula.

*Table 19: Presence of the DP sciences subject group learning outcome themes in the OSSD science/physics curricula*

| Themes extracted from the learning outcomes of the DP sciences subject group | Presence in the OSSD | |
|---|---|---|
| 1. Conceptual understanding and making connections | | Mostly present. Conceptual knowledge is referred to in Goal 3. Making connections is referred to in Goal 1, but with regard to the real-world, rather than within science. |
| 2. Use and application of knowledge, methods, tools, and techniques that characterize science | | Present. Goal 3 |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, synthesis) | | Present. Critical and creative thinking skills are focused on in Goal 2. |
| 4. Skills for scientific inquiry | | Present. Skills for scientific investigation are the focus of Goal 2 |
| 5. Development of technological skills | | Present. Goal 1 describes 'technical literacy' |
| 6. Effective collaboration and communication | | Mostly present. Communication is focused on in Goal 2, however collaboration is not explicitly mentioned. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Present. Relating science to technology, society and the environment is the focus of Goal 1 |

Key:

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

*Presence of the DP's Learning Outcome Themes*

As can be seen from Table 19, all the DP's learning outcome themes are present in the OSSD, with only a couple of small differences. Firstly, the DP's theme regarding global and local issues and scientific implications is strongly evident in the OSSD. Indeed, designed to emphasise scientific, environmental, and technological literacy, Goal 1 focuses on relating science to technology, society, and the environment. From references to 'technological literacy' it follows that another of the DP's themes, developing technological skills, is also present in Goal 1.

Furthermore, the OSSD places similar significance on skills for scientific inquiry through Goal 2, which includes 'Developing Skills of Investigation and Communication'. There are four broad areas in which these skills are developed, namely 'Interpreting and planning', 'Performing and

recording', 'Analysing and interpreting', and 'Communication'. As well as combining to satisfy the DP's theme of scientific inquiry skills, some of these areas also evidence other themes. For example, 'Analysis and interpreting' and 'Interpreting and planning' detail skills such as brainstorming, formulating hypotheses, making predictions, thinking critically and logically, evaluating and analysing data, solving problems, drawing and justifying conclusions, and synthesis – thus the DP's theme of creativity and critical thinking is well evidenced in the OSSD. Furthermore, the area of 'Communication' details skills such as attention to detail, applying correct terminology, and using various forms and formats to communicate scientific ideas, information and results, hence the DP's theme of effective communication is well evidenced here. However, it can be noted that collaboration is not explicitly mentioned in the OSSD outcomes, although there is reference to oral communication.

Additionally, the DP's theme of using and applying knowledge, methods, tools, and techniques is not an explicit outcome in the OSSD but is obviously implied throughout the Goals. Finally, Goal 3 refers to 'conceptual knowledge' students are expected to understand, which aligns with the DP's theme regarding conceptual understanding. Moreover, making connections is a feature within the OSSD's outcomes, however emphasis is on connections to the real-world, rather than within and between scientific disciplines.

*Other Themes in the OSSD*

Although the OSSD sets out goals which are applicable to all science courses, unlike the DP it also presents specific overall expectations within each course. Each course is split into strands, each of which have three overall expectations, informed by the goals. When contextualising the goals with courses' overall expectations, one immediate difference which emerges is that the OSSD has a clear focus on Canadians' contributions to the field, and the recognition of indigenous peoples' knowledge and customs. This focus gives the OSSD science courses a more nationalistic rooted identity, whereas the DP outcomes are framed around global and international perspectives.

Furthermore, an overall expectation which is common to all science courses in the OSSD is 'identify and describe careers related to the fields of science under study to those fields', hence the OSSD outcomes explicitly expect students to show an understanding of the careers that study of science can relate/lead to. By contrast, the DP's learning outcomes do not make this explicit link to careers, thus the OSSD emphasises the movement between study and the workplace more. However, by the nature of the OSSD UP courses and the DP, both have a focus towards further tertiary study. This would be accessing university level courses majoring in physics or related disciplines such as engineering or other sciences.

*Summary*

The science learning outcomes of the DP and OSSD are highly aligned. The programmes contain very similar learning outcome themes for their science courses, with only small differences emerging.

### 5.2.2 Content – Physics

This section compares and contrasts the content of the DP and OSSD curricula falling within the category of physics. In order to support visual comparison at-a-glance, the DP and OSSD

physics curricula are presented below in diagrams which show the key topics and sub-topics included in each.

*Figure 15: DP physics content visualiser*[78]

| | | | | | |
|---|---|---|---|---|---|
| **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 | | |

[78] '(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 16: Ontario science grades 9-10 content visualiser*

| | | | | | |
|---|---|---|---|---|---|
| **Science, grade 9, Academic** | **Biology** | Ecosystems consist of a variety of components, including, in many cases, humans. | The sustainability of ecosystems depends on balanced interactions between their components. | Human activity can affect the sustainability of aquatic and terrestrial ecosystems. | |
| | **Chemistry** | Elements and compounds have specific properties that determine their uses. | The use of elements and compounds has both positive and negative effects on society and the environment. | | |
| | **Earth and Space Science** | Celestial objects in the solar system and universe have specific properties that can be investigated and understood. | Technologies developed for space exploration have practical applications on Earth. | | |
| | **Physics** | Electricity is a form of energy produced from a variety of non-renewable and renewable sources. | The production and consumption of electrical energy has social, economic, and environmental implications. | Static and current electricity have distinct properties that determine how they are used. | |
| **Science, grade 10, Academic** | **Biology** | Plants and animals, including humans, are made of specialized cells, tissues, and organs that are organized into systems. | Developments in medicine and medical technology can have social and ethical implications. | | |
| | **Chemistry** | Chemicals react with each other in predictable ways. | Chemical reactions may have a negative impact on the environment, but they can also be used to address environmental challenges. | | |
| | **Earth and Space Science** | Earth's climate is dynamic and is the result of interacting systems and processes. | Global climate change is influenced by both natural and human factors. | Climate change affects living things and natural systems in a variety of ways. | People have the responsibility to assess their impact on climate change and to identify effective courses of action to reduce this impact. |
| | **Physics** | Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses. | Society has benefited from the development of a range of optical devices and technologies. | | |

*Figure 17: Ontario physics grades 11-12 content visualiser*

| | | | | | | |
|---|---|---|---|---|---|---|
| **Physics, Grade 11, University Preparation** | **Kinematics** | Motion involves a change in the position of an object over time. | Motion can be described using mathematical relationships. | Many technologies that apply concepts related to kinematics have societal and environmental implications. | | |
| | **Forces** | Forces can change the motion of an object. | Applications of Newton's laws of motion have led to technological developments that affect society and the environment. | | | |
| | **Energy and Society** | Energy can be transformed from one type to another. | Energy transformation systems often involve thermal energy losses and are never 100% efficient. | Although technological applications that involve energy transformations can affect society and the environment in positive ways, they can also have negative effects, and therefore must be used responsibly. | | |
| | **Waves and Sound** | Mechanical waves have specific characteristics and predictable properties. | Sound is a mechanical wave. | Mechanical waves can affect structures, society, and the environment in positive and negative ways. | | |
| | **Electricity and Magnetism** | Relationships between electricity and magnetism are predictable. | Electricity and magnetism have many technological applications. | Technological applications that involve electromagnetism and energy transformations can affect society and the environment in positive and negative ways. | | |
| **Physics, Grade 12, University Preparation** | **Dynamics** | Forces affect motion in predictable and quantifiable ways. | Forces acting on an object will determine the motion of that object. | Many technologies that utilize the principles of dynamics have societal and environmental implications. | | |
| | **Energy and Momentum** | Energy and momentum are conserved in all interactions. | Interactions involving the laws of conservation of energy and conservation of momentum can be analysed mathematically. | Technological applications that involve energy and momentum can affect society and the environment in positive and negative ways. | | |
| | **Gravitational, Electric, and Magnetic Fields** | Gravitational, electric, and magnetic forces act on matter from a distance. | Gravitational, electric, and magnetic fields share many similar properties. | The behaviour of matter in gravitational, electric, and magnetic fields can be described mathematically. | Technological systems that involve gravitational, electric, and magnetic fields can have an effect on society and the environment. | |
| | **The Wave Nature of Light** | Light has properties that are similar to the properties of mechanical waves. | The behaviour of light as a wave can be described mathematically. | Technologies that use the principles of the wave nature of light can have societal and environmental implications. | | |
| | **Revolutions in Modern Physics: Quantum Mechanics and Special Relativity** | Light can show particle-like and wave-like behaviour, and particles can show wave-like behaviour. | The behaviour of light as a particle and the behaviour of particles as waves can be described mathematically. | Time is relative to a person's frame of reference. | The effects of relativistic motion can be described mathematically. | New theories can change scientific thought and lead to the development of new technologies. |

*Structure*

The Ontario curriculum for grades 9 and 10 offers general science study split into academic and applied content. In grades 11 and 12, students can choose between specific subjects (e.g. biology, chemistry, physics, and earth and space science) and within those subjects, students can choose between destination-related courses depending on their post high school ambitions (e.g. university preparation, university/college preparation, college preparation, and workplace preparation courses). There are prerequisites to have completed some of the grade 9 and 10 courses to progress to grade 11 and 12 courses, but these differ depending on the destination-related course a student chooses to study. For example, completion of either the academic or the applied grade 9 course allows students to proceed directly to the grade 11 workplace preparation course. The Ontario courses outlined in the grades 9 to 12 science curriculum documents are designed as full-credit courses (100 hours of study). However, except for the grade 12 university preparation and university/college preparation courses, they may also be delivered as half-credit courses (50 hours of study).

By comparison, progression through DP physics is simpler. The DP has a recommended two years of study and a larger time allocation (150 hours for SL and 240 hours for HL), which is appropriate as it covers more content than the Ontario curriculum. The only pre-requisite stated for DP study is to have covered SL content before progressing to HL content and, if a student wishes to study HL, it is advisable that they have some prior scientific knowledge.

The overall focus of the Ontario curriculum is on the understanding of basic concepts, development of key skills for scientific inquiry and relating science to technology, society and the environment. There is an effort to make it Canada focused, for example 'describe the contributions of scientists, including Canadians' is often expressly stated. These elements are similar to the DP, but the DP has an international focus instead.

Opportunities for investigation and experimentation are outlined in each of the Ontario courses; however, it is unclear how teacher-led these may be. 30% of the final assessment of the Ontario courses is in the form of an examination, performance, essay, and/or another method of evaluation suitable to the course content and administered towards the end of the course. This could provide scope for an extended, self-directed investigation but this would be more varied, subjective, and not necessarily comparable to the opportunities for investigation given to DP students through their internal assessments (IA) and collaborative sciences project.

*Content Alignment*

The rest of the physics analysis will focus on grades 11 and 12, rather than grades 9 and 10. Indeed, the studies in the first two years of the OSSD are more typical of learning *prior* to upper secondary, hence there is alignment with these grades and more meaningful comparisons to the DP can be drawn from the last two years of Ontario's secondary school education.

To complement the analysis on content alignment, the figure below represents a simplified summary of the OSSD's content alignment, at topic-level, with DP physics (SL and HL).[79]

[79] The content of grades 9 and 10 was also mapped but is not represented in the table. Very little alignment was found with these grades due to their content being more typical of prior learning to upper secondary physics.

*Figure 18: Summary of the content alignment between the DP physics topics and the OSSD physics grade 11 (university preparation)*

| DP physics subtopics | SL presence in OSSD grade 11 physics | AHL presence in OSSD grade 11 physics |
|---|---|---|
| **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 | Covered in OSSD chemistry grade 11 | 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 | Covered in OSSD chemistry grade 12 | |
| E.2 Quantum physics | N/A | |
| E.3 Radioactive decay | | |
| E.4 Fission | | N/A |
| E.5 Fusion and stars | Partially covered in Earth and Space Science | N/A |
| Experimental programme | | |

Key:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Strong presence of this topic in the OSSD.* | | *Partial presence of this topic in the OSSD.* | | *Little or no presence of this topic in the OSSD.* | N/A | *This topic does not exist at the respective level.* |

*Figure 19: Summary of the content alignment between the DP physics topics and the OSSD physics grades 11 and 12 (university preparation)*

| DP physics subtopics | SL presence in OSSD grade 12 physics | AHL presence in OSSD grade 12 physics |
|---|---|---|
| **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 | Covered in OSSD chemistry grade 11 | 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 | Covered in OSSD chemistry grade 12 | |
| E.2 Quantum physics | N/A | |
| E.3 Radioactive decay | | |
| E.4 Fission | | N/A |
| E.5 Fusion and stars | Partially covered in Earth and Space Science | N/A |
| Experimental programme | | |

Key:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Strong presence of this topic in the OSSD.* | | *Partial presence of this topic in the OSSD.* | | *Little or no presence of this topic in the OSSD.* | N/A | *This topic does not exist at the respective level.* |

*NB: Where applicable, content alignments found in pre-requisite subjects are carried forwards and combined with new alignments to represent the cumulative content covered.*

As can be seen from the figure and tables above, there is significant alignment between the topic coverage in the DP physics and the OSSD physics, though the level of depth and breadth are greater in the DP.

The DP curriculum covers all the content which is covered by the Ontario curriculum, going into greater depth and breadth for all topics, and the overall mathematical demand for DP is greater than that for Ontario. The boundaries between the science subjects differ slightly so it is worth noting that some content missing from the Ontario physics curriculum can be found elsewhere. The DP topics ‘gas laws’ and ‘structure of the atom’ are covered in OSSD chemistry, while ‘fusion and stars’ is partially covered in OSSD earth and space science.

SL ‘space, time and motion’ is the only topic to be fully and comparably covered by the Ontario curriculum. Of the 19 DP SL sub-topics, just over half are covered in comparable depth and breadth by the OSSD physics curriculum, with the remaining sub-topics being partially covered and often lacking the same level of detail or quantitative description. For example, the Ontario curriculum asks students to ‘describe and explain’ simple harmonic motion, whereas DP SL requires students to know the defining and other descriptive equations. The only SL physics

sub-topic to be almost fully absent from the Ontario science curriculum is B.2 Greenhouse effect – this phenomenon is mentioned in various topics and sample issues but is covered in less or differing detail.

None of the DP HL topics are covered by Ontario in comparable depth or breadth and only a third of the sub-topics are partially covered. No comparable content was found in the Ontario curriculum for the DP HL sub-topics radioactive decay, electrical and magnetic fields, gravitational fields, and thermodynamics.

*Table 20: OSSD physics content which is not covered in the DP*

| Significant OSSD physics content which is not included in the DP* |
|---|
| ○ All significant content is covered by DP physics. |

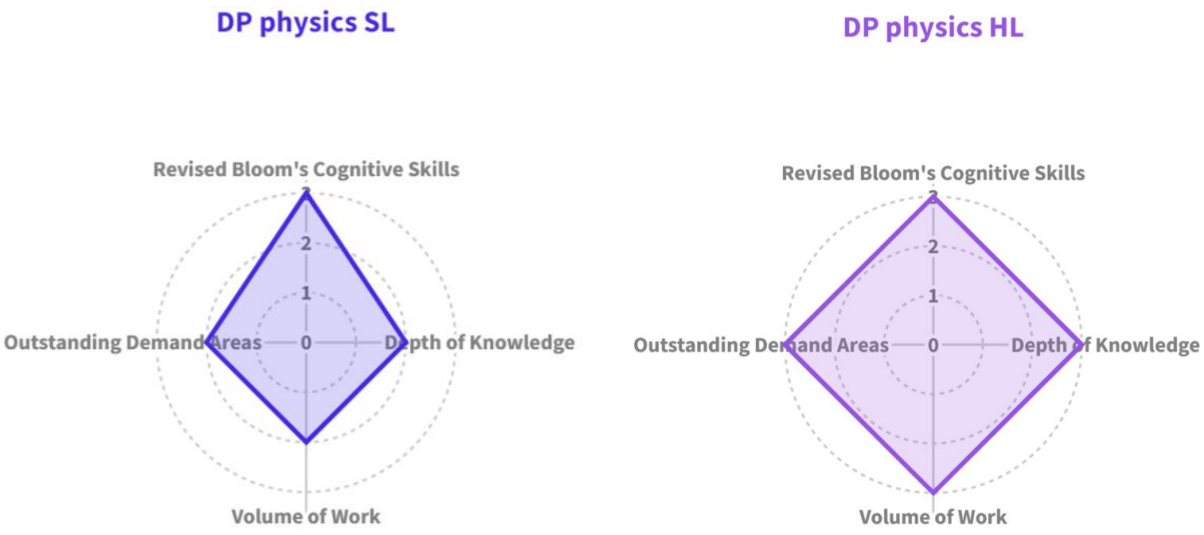
* Significant content mostly does not include topics which are typically studied *prior* to upper secondary

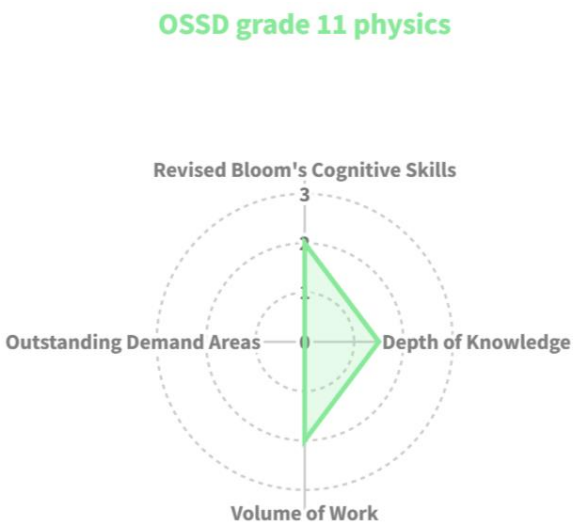
Overall, the content in OSSD physics grades 11 and 12 more closely aligns with DP physics SL than DP physics HL, though it features less breadth and depth than the DP at both SL and HL.

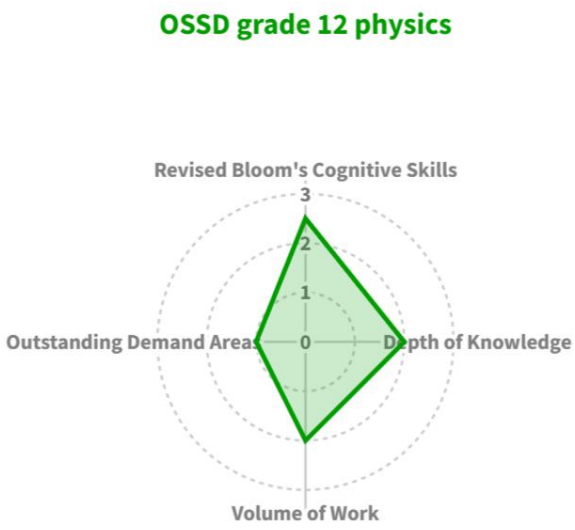
### 5.2.3 Demand – Physics

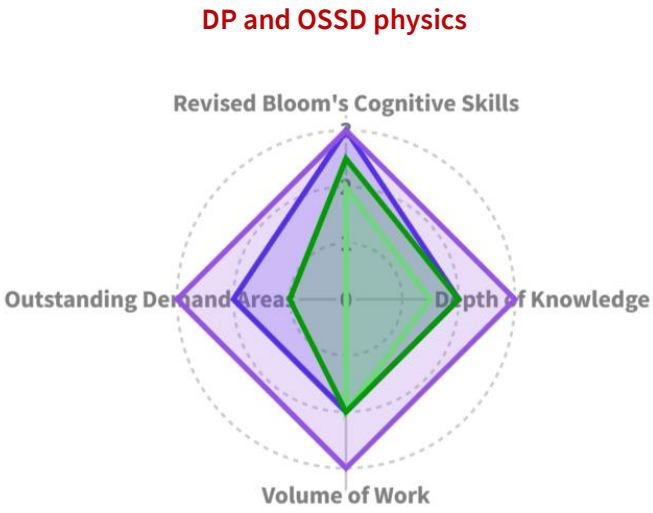
The DP and OSSD curricula were analysed using the same demand tool in order to create a demand profile for DP physics SL, DP physics HL, OSSD grade 11 physics, and OSSD grade 12 physics. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles 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 critical thinking, critical awareness and elements of synthesis and creation present in the majority of Aims and Assessment Objective 3.
  - For Ontario, a score of 2 was awarded to grade 11 physics due to the course's primary focus on analysis and application, as well as some (though limited) presence of evaluative skills. Grade 12 physics was deemed to feature a more substantial focus on evaluation, creation and independent investigation, though a

considerable number of learning outcomes still focused on application – as a result, the course was judged to merit a 2.5 Bloom's demand score.

- Regarding the score 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 Ontario, grade 11 physics was judged to merit a score of 1.5 due to the considerable prior knowledge required to access the course and the fact that a significant proportion of topics is studied in considerable detail. Finally, OSSD grade 12 physics was warranted a score of 2 as, although the primary focus of the course was still found to be on knowledge application rather than more complex reasoning, many topics were found to be studied in higher detail. The absence of clear opportunities for higher-order thinking prevented the course from achieving a score of 3.

- Regarding the scores for **Volume of Work**:
  - The 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 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 as, even though the number of topics per hour is smaller, these topics are covered in great depth and with a focus on application.
  - For Ontario, for grade 11 and grade 12 physics, a score of 2 was awarded as the courses were seen to include added depth of content (when compared to their pre-secondary counterparts) and feature a moderate to high number of topics and sub-topics, with typical time allocation per topic.

- Regarding the scores for **Outstanding Areas of Subject Demand**:
  - For the DP physics SL course (awarded a score of 2), the IA scientific investigation research project that students need to undertake, the linking questions outlined in the syllabus and the collaborative sciences project were considered to be areas of stretch. In addition to the latter, the HL course features additional higher-level topics which were deemed to include additional areas of stretch, meriting a score of 3.
  - For Ontario grade 11 physics, no clear stretch areas were found. Although a potential opportunity for stretch was identified in the project work, the requirements for the latter were not clearly documented and, as no other areas of stretch were identified, the panel awarded all three courses a score of 0 for stretch. For grade 12 physics, the topic of 'Revolutions in Modern Physics: Quantum Mechanics and Special Relativity' was deemed to constitute a stretch area, awarding the course a score of 1 for this category.

## 5.3 Chemistry

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

**DP chemistry**[80]
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.

**OSSD grades 9 and 10 science: Academic**[81]
Grades 9 and 10 are split into two streams, Academic and Applied. For the purposes of this report, the Academic stream and following courses will be the focus. The different areas of science are integrated at this grade to include concepts in chemistry, biology, physics, and earth and space science. The academic stream develops students' skills through the study of theory and abstract problems, whereas the applied stream emphasises practical applications. Students need to study the grade 10 Academic course to be able to access UP chemistry courses.

**OSSD grades 11 and 12 chemistry: University Preparation**[82]
Grades 11 and 12 offer University Preparation, University/College Preparation, College Preparation, and Workplace courses. For the purposes of this report, the courses offered in University Preparation will be the focus. Chemistry is offered as a course from grade 11 and can be continued on to grade 12. These courses will prepare students for further study and are designed to satisfy university science programme requirements.

### 5.3.1 Learning Outcomes – Chemistry

This section compares and contrasts the learning outcomes of curricula falling within the category of 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. Similarly, the OSSD sets out three goals which are the same for all science courses. These goals inform the three overall expectations found in each strand of a course; they also underlie assessment of student achievement. The OSSD goals are the following:

- Goal 1. To relate science to technology, society, and the environment.
- Goal 2. To develop the skills, strategies, and habits of mind required for scientific investigation.
- Goal 3. To understand the basic concepts of science.

[80] International Baccalaureate. (2023). *Chemistry guide*.
[81] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 9 and 10 Science.*
[82] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 11 and 12 Science.*

Since the OSSD sets out the same goals which inform all of its science subjects, the results from the learning outcome comparison analysis are the same for chemistry as they are for physics. Therefore, this section includes the summary table again, followed by a shortened overview of the findings. Full detail on the comparison analysis of learning outcomes is available in 5.2.1 Learning Outcomes - Physics.

The following table demonstrates the learning outcome themes that were extracted from the DP learning outcomes and indicates if and where they were judged to have presence within the learning outcomes of the OSSD chemistry curricula.

*Table 21: Presence of the DP sciences subject group learning outcome themes in the OSSD science/chemistry curricula*

| Themes extracted from the learning outcomes of the DP sciences subject group | Presence in OSSD | |
|---|---|---|
| 1. Conceptual understanding and making connections | | Mostly present. Conceptual knowledge is referred to in Goal 3. Making connections is referred to in Goal 1, but with regard to the real-world, rather than within science. |
| 2. Use and application of knowledge, methods, tools, and techniques that characterize science | | Present. Goal 3 |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, synthesis) | | Present. Critical and creative thinking skills are focused on in Goal 2. |
| 4. Skills for scientific inquiry | | Present. Skills for scientific inquiry are the focus of Goal 2 |
| 5. Development of technological skills | | Present. Goal 1 describes ‘technical literacy’ |
| 6. Effective collaboration and communication | | Mostly present. Communication is focused on in Goal 2, however collaboration is not explicitly mentioned. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Present. Relating science to technology, society and the environment is the focus of Goal 1 |

Key:

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

Summary
The science learning outcomes of the DP and OSSD are highly aligned. Goal 1 from the OSSD aligns with the DP's themes of developing technological skills and considering the impact of science on society and the environment. Goal 2 contains 'Developing Skills of Investigation and Communication' and aligns with the DP's themes of effective communication, inquiry skills, and creative and critical thinking. Goal 3 aligns with the DP's theme of developing conceptual understanding – though worded as 'conceptual knowledge'. The DP's last theme of acquiring and applying knowledge, tools and methods is implied in Goal 1 and the skill-focused Goal 2 and complemented by 'understanding basic concepts' in Goal 3. Therefore, all of the DP's themes are found to be present in the OSSD, with slight differences in wording and emphasis. Finally, the OSSD contains a few differences to the DP in that it is more nationalistic – it focuses on Canadian contributions to the field and recognition of indigenous peoples' knowledge and customs – and also includes exploration of related science careers.

### 5.3.2 Content – Chemistry

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

*Figure 21: DP chemistry content visualiser*[83]

| | | | | | | |
|---|---|---|---|---|---|---|
| **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 from fuels | 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 | | | |

[83] '(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: Ontario science grades 9-10 content visualiser*

| | | | | | |
|---|---|---|---|---|---|
| **Science, grade 9, Academic** | **Biology** | Ecosystems consist of a variety of components, including, in many cases, humans. | The sustainability of ecosystems depends on balanced interactions between their components. | Human activity can affect the sustainability of aquatic and terrestrial ecosystems. | |
| | **Chemistry** | Elements and compounds have specific properties that determine their uses. | The use of elements and compounds has both positive and negative effects on society and the environment. | | |
| | **Earth and Space Science** | Celestial objects in the solar system and universe have specific properties that can be investigated and understood. | Technologies developed for space exploration have practical applications on Earth. | | |
| | **Physics** | Electricity is a form of energy produced from a variety of non-renewable and renewable sources. | The production and consumption of electrical energy has social, economic, and environmental implications. | Static and current electricity have distinct properties that determine how they are used. | |
| **Science, grade 10, Academic** | **Biology** | Plants and animals, including humans, are made of specialized cells, tissues, and organs that are organized into systems. | Developments in medicine and medical technology can have social and ethical implications. | | |
| | **Chemistry** | Chemicals react with each other in predictable ways. | Chemical reactions may have a negative impact on the environment, but they can also be used to address environmental challenges. | | |
| | **Earth and Space Science** | Earth's climate is dynamic and is the result of interacting systems and processes. | Global climate change is influenced by both natural and human factors. | Climate change affects living things and natural systems in a variety of ways. | People have the responsibility to assess their impact on climate change and to identify effective courses of action to reduce this impact. |
| | **Physics** | Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses. | Society has benefited from the development of a range of optical devices and technologies. | | |

*Figure 2318: Ontario chemistry grades 11-12 content visualiser*

| | | | | |
|---|---|---|---|---|
| **Chemistry, grade 11, University Preparation** | **Matter, Chemical Trends, and Chemical bonding** | Every element has predictable chemical and physical properties determined by its structure. | The type of chemical bond in a compound determines the physical and chemical properties of that compound. | It is important to use chemicals properly to minimize the risks to human health and the environment |
| | **Chemical Reactions** | Chemicals react in predictable ways | Chemical reactions and their applications have significant implications for society and the environment. | |
| | **Quantities in Chemical Reaction** | Relationships in chemical reactions can be described quantitatively | The efficiency of chemical reactions can be determined and optimized by applying an understanding of quantitative relationships in such reactions. | |
| | **Solutions and Solubility** | Properties of solutions can be described qualitatively and quantitatively, and can be predicted. | Living things depend for their survival on the unique physical and chemical properties of water. | People have a responsibility to protect the integrity of Earth's water resources |
| | **Gases and Atmospheric Chemistry** | Properties of gases can be described qualitatively and quantitatively, and can be predicted. | People have a responsibility to protect the integrity of Earth's atmosphere. | |
| **Chemistry, grade 12, University Preparation** | **Organic Chemistry** | Organic compounds have predictable chemical and physical properties determined by their respective structures. | Organic chemical reactions and their applications have significant implications for society, human health, and the environment. | |
| | **Structure and Properties of Matter** | The nature of the attractive forces that exist between particles in a substance determines the properties and limits the uses of that substance. | Technological devices that are based on the principles of atomic and molecular structures can have societal benefits and costs. | |
| | **Energy Changes and Rates of Reaction** | Energy changes and rates of chemical reactions can be described quantitatively. | Efficiency of chemical reactions can be improved by applying optimal conditions. | Technologies that transform energy can have societal and environmental costs and benefits. |
| | **Chemical Systems and Equilibrium** | Chemical systems are dynamic and respond to changing conditions in predictable ways | Chemical systems are dynamic and respond to changing conditions in predictable ways | |
| | **Electrochemistry** | Oxidation and reduction are paired chemical reactions in which electrons are transferred from one substance to another in a predictable way. | The control and applications of oxidation and reduction reactions have significant implications for industry, health and safety, and the environment. | |

*Structure*

As mentioned in the physics section, the Ontario curriculum for grades 9 and 10 offers general science study split into academic and applied content. In grades 11 and 12, students can choose between specific subjects (e.g. biology, chemistry, physics, earth and space science) and, within those subjects, can choose between destination-related courses depending on their post high school ambitions (e.g. university preparation, university/college preparation, college preparation, and workplace preparation courses). There are prerequisites to have completed some of the grade 9 and 10 courses to progress to grade 11 and 12 courses, but these differ depending on the destination-related course a student chooses to study – e.g. completion of either the academic or the applied grade 9 course allows students to proceed directly to the grade 11 workplace preparation course. The Ontario courses outlined in the grades 9 to 12 science curriculum documents are designed as full-credit courses (100 hours of study). However, except for the grade 12 university preparation and university/college preparation courses, they may also be delivered as half-credit courses (50 hours of study).

By comparison, progression through DP chemistry is simpler – the only pre-requisite stated for DP study is to have covered SL content before progressing to HL content and, if a student wishes to study HL, it is advisable that they have some prior scientific knowledge.

Both courses emphasise, and provide opportunities for, investigation and experimentation. The DP chemistry course stipulates that students should show awareness of the purpose and practice of 13 chemistry techniques, outlined in Tool 1: Experimental Techniques, and OSSD chemistry shares coverage of the majority of those techniques, with exception of melting point determination, recrystallisation, paper chromatography, calorimetry, or drying to a constant mass.

Additionally, 30% of the final assessment in the OSSD courses is in the form of an examination, performance, essay, and/or other method of evaluation suitable to the course content and administered towards the end of the course, which could provide scope for an extended, self-directed investigation. However, the assessment method and scope vary from school to school and may not always, as a result, be comparable to the opportunities for investigation given to DP students through their IAs and collaborative sciences project.

*Content alignment*

The rest of the chemistry analysis will focus on grades 11 and 12, rather than grades 9 and 10. Indeed, the studies in the first two years of the OSSD are more typical of learning *prior* to upper secondary, hence there is alignment with these grades and more meaningful comparisons to the DP can be drawn from the last two years of Ontario's secondary school education.

To complement the analysis on content alignment, the figures below represent a simplified summary of the OSSD's content alignment, at topic-level, with DP chemistry (SL and HL).[84]

[84] The content of grades 9 and 10 was also mapped but is not represented in the table. Very little alignment was found with these grades due to their content being more typical of prior learning to upper secondary chemistry.

*Figure 24: Summary of content alignment between the DP chemistry topics and the OSSD chemistry grade 11 (university preparation)*

| DP chemistry topics | Presence of SL content in the OSSD grade 11 chemistry | Presence of AHL content in the OSSD grade 11 chemistry |
|---|---|---|
| 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 | | |

*Figure 25: Summary of content alignment between the DP chemistry topics and the OSSD chemistry grades 11 and 12 (university preparation)*

| DP chemistry topics | Presence of SL content in the OSSD | Presence of AHL content in the OSSD |
|---|---|---|
| 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:

| | | | | | |
|---|---|---|---|---|---|
| | *Strong presence of this topic in the OSSD* | | *Partial presence of this topic in the OSSD* | | *Little or no presence of this topic in the OSSD* |

*NB: Where applicable, content alignments found in pre-requisite subjects are carried forwards and combined with new alignments to represent the cumulative content covered.*

There is a high degree of content alignment between the OSSD and DP chemistry curricula, with the DP covering all of the significant OSSD chemistry topics and the OSSD covering all 21 SL sub-topics to either a partial or full extent. More specifically, there is similar coverage of the structure of matter and atomic structure, chemical bonding, chemical reactions/processes, and energy.

Some topics in the OSSD grade 12 chemistry course are covered in more depth than the core SL material in the DP course. However, the DP HL curriculum goes into greater depth than the OSSD curriculum in multiple areas, including the covalent model, electron pair-sharing reactions and classification of organic compounds. Furthermore, the HL course also covers the topic of entropy and spontaneity, which is entirely absent from the OSSD.

Overall, there is significant alignment between the DP and Ontario in terms of the main topics covered in the chemistry courses. Both spend a large proportion of their allotted time covering key areas of chemistry such as reactions, bonding, acids, and practical aspects of measuring chemical processes. The AHL content included within the DP curriculum exceed in depth and complexity some parts of the OSSD curricula.

*Table 22: OSSD chemistry content which is not covered in the DP*

| Significant OSSD chemistry content which is not included in the DP* |
|---|
| ○ All significant content is covered by DP chemistry. |

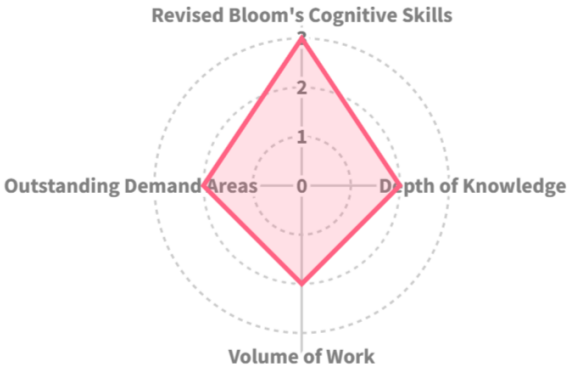
* Significant content mostly does not include topics which are typically studied *prior* to upper secondary

### 5.3.3 Demand – Chemistry

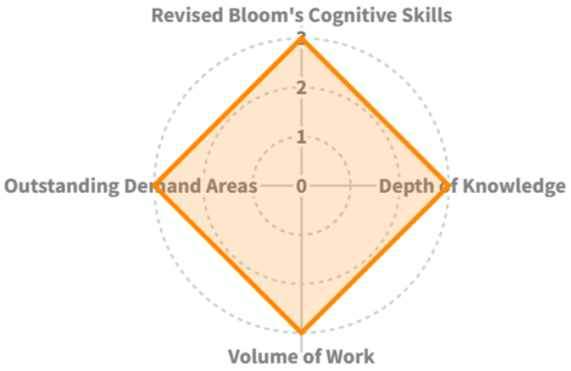
The DP and OSSD curricula were analysed using the same demand tool in order to create a demand profile for DP chemistry SL, DP chemistry HL, OSSD grade 11 chemistry, and OSSD grade 12 chemistry. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles superimposed in one place, enabling immediate visual comparison.

*Figure 26: Visual representations of subject demand*

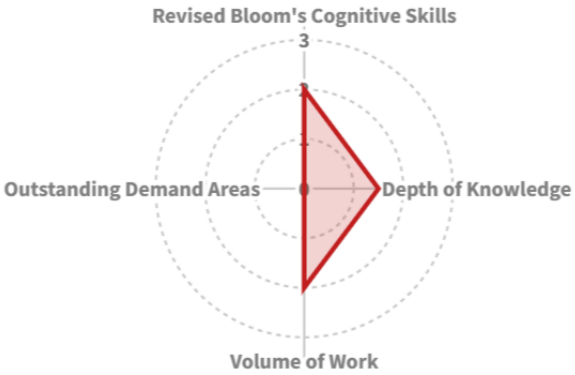
**DP chemistry SL**



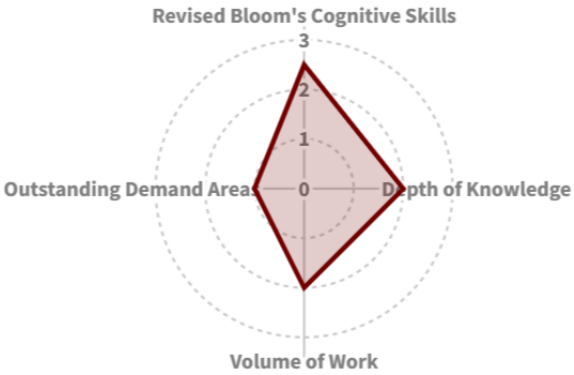

**DP chemistry HL**



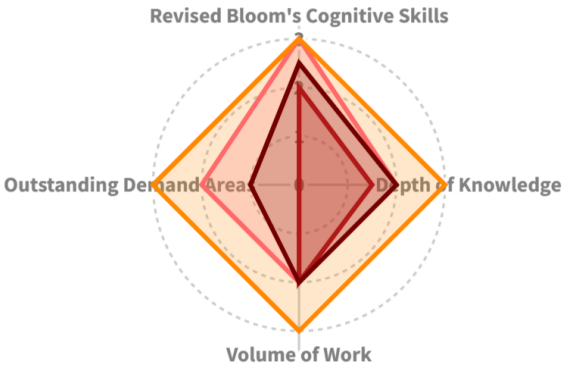

**OSSD grade 11 chemistry**




**OSSD grade 12 chemistry**




**DP and OSSD chemistry**



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 Objectives 3.
  - A score of 2 was awarded to grade 11 chemistry due to the course's primary focus on analysis and application, as well as some (though limited) presence of evaluative skills. For grade 12 chemistry, though a considerable number of learning outcomes still focused on application, a more substantial focus on analysis was observed – as a result, the course was judged to merit a 2.5 Bloom's demand score.

- Regarding the score 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.
  - OSSD grade 11 chemistry was judged to merit a score of 1.5 due to the considerable prior knowledge required to access the course and the expectation that students conduct some analysis (compare and contrast) as well as demonstrate greater depth of understanding in certain topic areas. OSSD grade 12 chemistry, in turn, was given a score of 2 as, although many topics were found to be studied in higher detail, the primary focus of the course was found to be on knowledge application rather than more complex reasoning. The absence of clear opportunities for higher-order thinking prevented the course from achieving a score of 3.

- 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 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.
  - For Ontario grade 11 and grade 12 chemistry, a score of 2 was awarded. Both courses were seen to include added depth of content (when compared to their pre-secondary counterparts) and although students only study six units of work, the number of themes and concepts covered was judged to be typical to high and the time allocation per topic was considered standard.

- Regarding the scores for **Outstanding Areas of Subject Demand**:
  - For the DP chemistry SL course (awarded a score of 2), the IA scientific investigation research project that students need to undertake, the linking questions outlined in the syllabus and the collaborative sciences project were considered to be areas of stretch. In addition to the latter, the HL course features additional higher-level topics which were deemed to include additional areas of stretch, meriting a score of 3.
  - For Ontario grade 11 chemistry no obvious stretch areas were found. For grade 12 chemistry, the broad nature of the sample questions and the fact that some drew upon knowledge from multiple scientific subjects were seen to constitute a stretch area, awarding the course a score of 1 for this category.

## 5.4 Biology

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

**DP biology**[85]
Biology is a subject option within 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 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.

**OSSD grades 9 and 10 science: Academic**[86]
Grades 9 and 10 are split into two streams, Academic and Applied. For the purposes of this report, the Academic stream and following courses will be the focus. The different areas of science are integrated at this grade to include concepts in chemistry, biology, physics, and earth and space science. The academic stream develops students' skills through the study of theory and abstract problems, whereas the applied stream emphasises practical applications. Students need to study the grade 10 Academic course to be able to access UP biology courses.

**OSSD grades 11 and 12 biology: University Preparation**[87]
Grades 11 and 12 offer University Preparation courses, University/College Preparation courses, College Preparation courses, and Workplace courses. For the purposes of this report, the courses offered in University Preparation will be the focus. Biology is offered as a course from grade 11 and can be continued onto grade 12. These courses are intended to prepare students for further study and enable progression to higher education in biology-related subjects.

### 5.4.1 Learning Outcomes – Biology

This section compares and contrasts the learning outcomes of curricula falling within the category of biology.

The learning outcome themes for biology 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. Similarly, the OSSD sets out three goals which are the same for all science courses. These goals inform the three overall expectations found in each strand of a course; they also underlie assessment of student achievement.
The OSSD goals are the following:

- Goal 1. To relate science to technology, society, and the environment.
- Goal 2. To develop the skills, strategies, and habits of mind required for scientific investigation.

[85] International Baccalaureate. (2023). *Biology guide*.
[86] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 9 and 10 Science.*
[87] Government of Ontario, Ministry of Education. (2008). *The Ontario Curriculum Grades 11 and 12 Science.*

- Goal 3. To understand the basic concepts of science.

Since the OSSD sets out the same goals which inform all of its science subjects, the results from the learning outcome comparison analysis are the same for biology as they are for physics. Therefore, this section includes the summary table again, followed by a shortened overview of the findings. Full detail on learning outcomes comparison analysis is available in 5.2.1 Physics.

The following table demonstrates the learning outcome themes that were extracted from the DP learning outcomes and indicates if and where they were judged to have presence within the learning outcomes of the OSSD biology curricula.

*Table 23: Presence of the DP sciences learning outcome themes in the OSSD science/biology curricula*

| Themes extracted from the learning outcomes of the DP sciences subject group | Presence in Ontario's (OSSD) learning outcomes for science | |
|---|---|---|
| 1. Conceptual understanding and making connections | | Mostly present. Conceptual knowledge is referred to in Goal 3. Making connections is referred to in Goal 1, but with regard to the real-world, rather than within science. |
| 2. Acquisition and application of knowledge, methods, tools, and techniques that characterize science | | Present. Goal 3 deals with acquisition of knowledge and theme is implied in other Goals |
| 3. Creativity and critical thinking (problem-solving, analysis, evaluation, synthesis) | | Present. Critical and creative thinking skills are focused on in Goal 2. |
| 4. Skills for scientific inquiry | | Present. Skills for scientific inquiry are the focus of Goal 2 |
| 5. Development of technological skills | | Present. Goal 1 describes 'technical literacy' |
| 6. Effective collaboration and communication | | Mostly present. Communication is focused on in Goal 2, however collaboration is not explicitly mentioned. |
| 7. Awareness of global and local problems and the environmental, ethical, cultural, and social impact of science | | Present. Relating science to technology, society and the environment is the focus of Goal 1 |

Key:

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

Summary
The science learning outcomes of the DP and OSSD are highly aligned. Goal 1 from the OSSD aligns with the DP's themes of developing technological skills and considering the impact of science on society and the environment. Goal 2 contains 'Developing Skills of Investigation and Communication' and aligns with the DP's themes of effective communication, inquiry skills, and creative and critical thinking. Goal 3 aligns with the DP's theme of developing conceptual understanding – though worded as 'conceptual knowledge'. The DP's last theme of acquiring and applying knowledge, tools and methods is implied in Goal 1 and the skill-focused Goal 2 and complemented by 'understanding basic concepts' in Goal 3. Therefore, all of the DP's themes are found to be present in the OSSD, with slight differences on wording and emphasis. Finally, the OSSD contains a few differences to the DP in that it is more nationalistic – it focuses on Canadian contributions to the field and recognition of indigenous peoples' knowledge and customs – and also includes exploration of related science careers.

### 5.4.2 Content – Biology

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

*Figure 27: DP biology content visualiser*[88]

| | | | | |
|---|---|---|---|---|
| **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 | |

[88] '(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 28: Ontario science grades 9-10 content visualiser*

| | | | | | |
|---|---|---|---|---|---|
| **Science, grade 9, Academic** | **Biology** | Ecosystems consist of a variety of components, including, in many cases, humans. | The sustainability of ecosystems depends on balanced interactions between their components. | Human activity can affect the sustainability of aquatic and terrestrial ecosystems. | |
| | **Chemistry** | Elements and compounds have specific properties that determine their uses. | The use of elements and compounds has both positive and negative effects on society and the environment. | | |
| | **Earth and Space Science** | Celestial objects in the solar system and universe have specific properties that can be investigated and understood. | Technologies developed for space exploration have practical applications on Earth. | | |
| | **Physics** | Electricity is a form of energy produced from a variety of non-renewable and renewable sources. | The production and consumption of electrical energy has social, economic, and environmental implications. | Static and current electricity have distinct properties that determine how they are used. | |
| **Science, grade 10, Academic** | **Biology** | Plants and animals, including humans, are made of specialized cells, tissues, and organs that are organized into systems. | Developments in medicine and medical technology can have social and ethical implications. | | |
| | **Chemistry** | Chemicals react with each other in predictable ways. | Chemical reactions may have a negative impact on the environment, but they can also be used to address environmental challenges. | | |
| | **Earth and Space Science** | Earth's climate is dynamic and is the result of interacting systems and processes. | Global climate change is influenced by both natural and human factors. | Climate change affects living things and natural systems in a variety of ways. | People have the responsibility to assess their impact on climate change and to identify effective courses of action to reduce this impact. |
| | **Physics** | Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses. | Society has benefited from the development of a range of optical devices and technologies. | | |

*Figure 29: Ontario biology grades 11-12 content visualiser*

| | | | | |
|---|---|---|---|---|
| **Biology, grade 11, University Preparation** | **Diversity of Living Things** | All living things can be classified according to their anatomical and physiological characteristics. | Human activities affect the diversity of living things in ecosystems | |
| | **Evolution** | Evolution is the process of biological change over time based on the relationships between species and their environments | The theory of evolution is a scientific explanation based on a large accumulation of evidence | Technology that enables humans to manipulate the development of species has economic and environmental implications |
| | **Genetic Processes** | Genetic and genomic research can have social and environmental implications | Variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis | |
| | **Animals: Structure and Function** | Groups of organs with specific structures and functions work together as systems, which interact with other systems in the body | The development and uses of technology to maintain human health are based, in part, on the changing needs of society. | |
| | **Plants: Anatomy, Growth, and Function** | Plants: Anatomy, Growth, and Function Plants have specialized structures with distinct functions that enable them to respond and adapt to their environment. | Plant variety is critical to the survival and sustainability of ecosystems | |
| **Biology, grade 12, University Preparation** | **Biochemistry** | Technological applications that affect biological processes and cellular functions are used in the food, pharmaceutical, and medical industries. | Biological molecules and their chemical properties affect cellular processes and biochemical reactions | Biochemical compounds play important structural and functional roles in cells of all living organisms |
| | **Metabolic Processes** | All metabolic processes involve chemical changes and energy conversions. | An understanding of metabolic processes enables people to make informed choices with respect to a range of personal, societal, and environmental issues. | |
| | **Molecular Genetics** | DNA contains all the genetic information for any living organism. | Proteins control a wide variety of cellular processes. | Genetic research and biotechnology have social, legal, and ethical implications. |
| | **Homeostasis** | Organisms have strict limits on the internal conditions that they can tolerate. | Systems that maintain homeostasis rely on feedback mechanisms. | Environmental factors can affect homeostasis |
| | **Population Dynamics** | Population growth follows predictable patterns. | The increased consumption of resources and production of waste associated with population growth result in specific stresses that affect Earth's sustainability. | Technological developments can contribute to or help offset the ecological footprint associated with population growth and the consumption of natural resources |

*Structure*

As mentioned in the physics and chemistry sections, the Ontario curriculum for grades 9 and 10 offers general science study split into academic and applied content. In grades 11 and 12, students can choose between specific subjects (e.g. biology, chemistry, physics, earth and space science) and, within those subjects, can choose between destination-related courses depending on their post high school ambitions (e.g. university preparation, university/college preparation, college preparation, and workplace preparation courses). There are prerequisites to have completed some of the grade 9 and 10 courses to progress to grade 11 and 12 courses, but these differ depending on the destination-related course a student chooses to study – e.g. completion of either the academic or the applied grade 9 course allows students to proceed directly to the grade 11 workplace preparation course. The Ontario courses outlined in the grades 9 to 12 science curriculum documents are designed as full-credit courses (100 hours of study). However, except for the grade 12 university preparation and university/college preparation courses, they may also be delivered as half-credit courses (50 hours of study).

By comparison, progression through DP biology is simpler – the only pre-requisite stated for DP study is to have covered SL content before progressing to HL content and, if a student wishes to study HL, it is advisable that they have some prior scientific knowledge.

Both courses emphasise, and provide opportunities for, investigation and experimentation. The DP biology course stipulates that students should show awareness of the purpose and practice of ten biology techniques, outlined in Tool 1: Experimental Techniques, and the OSSD biology share coverage of six of those techniques, with exception of paper chromatography, colorimetry or spectrophotometry, serial dilutions or cladogram analysis.

Additionally, 30% of the final assessment in the OSSD courses is in the form of an examination, performance, essay, and/or other method of evaluation suitable to the course content and administered towards the end of the course, which could provide scope for an extended, self-directed investigation. However, the assessment method and scope vary from school to school and may not always, as a result, be comparable to the opportunities for investigation given to DP students through their IAs and collaborative sciences project.

*Content Alignment*

The rest of the biology analysis will focus on grades 11 and 12, rather than grades 9 and 10. Indeed, the studies in the first two years of the OSSD are more typical of learning *prior* to upper secondary, hence there is alignment with these grades and more meaningful comparisons to the DP can be drawn from the last two years of Ontario's secondary school education.

To complement the analysis on content alignment, the figures below represent a simplified summary of the OSSD's content alignment, at topic-level, with DP biology (SL and HL).[89]

[89] The content of grades 9 and 10 was also mapped but is not represented in the table. Very little alignment was found with these grades due to their content being more typical of prior learning to upper secondary biology.

*Figure 30: Summary of content alignment between the DP biology topics and OSSD grade 11 (university preparation)*

| DP biology topics | Presence of SL content in the OSSD grade 11 biology | Presence of AHL content in the OSSD grade 11 biology |
|---|---|---|
| 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 | | |

*Figure 31: Summary of content alignment between the DP biology topics and OSSD biology grades 11 and 12 combined (university preparation)*

| DP biology topics | Presence of SL content in the OSSD | Presence of AHL content in the OSSD |
|---|---|---|
| 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:

| | | | | | |
|---|---|---|---|---|---|
| | *Strong presence of this topic in the OSSD* | | *Partial presence of this topic in the OSSD* | | *Little or no presence of this topic in the OSSD* |

*NB: Where applicable, content alignments found in pre-requisite subjects are carried forwards and combined with new alignments to represent the cumulative content covered.*

There is a high level of alignment between the DP biology and OSSD biology courses, with both courses dedicating a substantial amount of learning hours to cells, molecules, genetics, ecology, evolution, plants, and animals/humans.

The DP SL covers all significant content in the OSSD biology course, and the latter covers all significant content in the DP SL course, with exception of water – which is absent from the OSSD – and climate change, which is covered in less detail.

When it comes to the HL, there is also significant overlap but a number of areas in the latter's AHL content exceeds the OSSD in both breadth and depth. For example, the OSSD does not feature comparable coverage of the AHL content on cell structure and respiration, evolution and speciation, protein synthesis, membranes and transport, cell specialisation, reproduction, homeostasis and genes, and it also does not cover muscle and mobility or chemical signalling.

Overall, there is a high level of alignment in the core topics covered within both courses, while there is also evidence that the HL sub-topics in the DP involve greater breadth or depth in specific areas.

*Table 24: OSSD biology content which is not covered in the DP*

| Significant OSSD biology content which is not included in the DP* |
|---|
| ○ All significant content is covered by DP biology. |

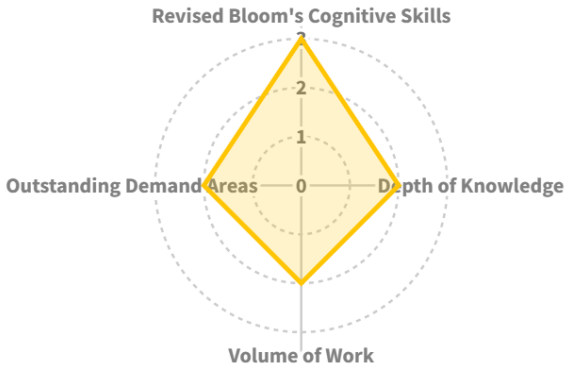
*Significant content mostly does not include topics which are typically studied *prior* to upper secondary.

### 5.4.3 Demand – Biology

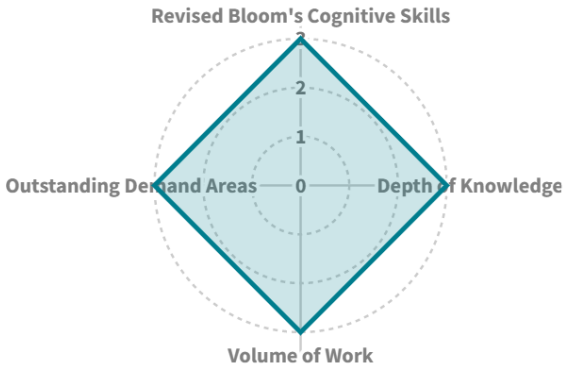
The DP and OSSD curricula were analysed using the same demand tool in order to create a demand profile for DP biology SL, DP biology HL, OSSD grade 11 biology, and OSSD grade 12 biology. These demand profiles are presented below in the form of radar diagrams, with the last diagram showing all profiles superimposed in one place, enabling immediate visual comparison.

*Figure 32: Visual representations of subject demand*

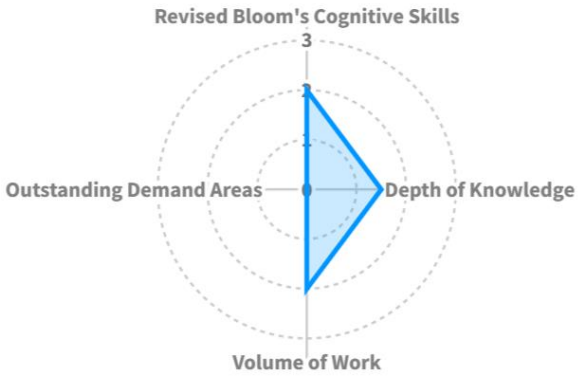
**DP biology SL**



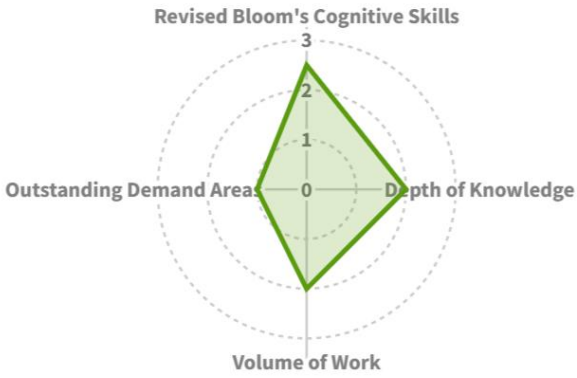

**DP biology HL**



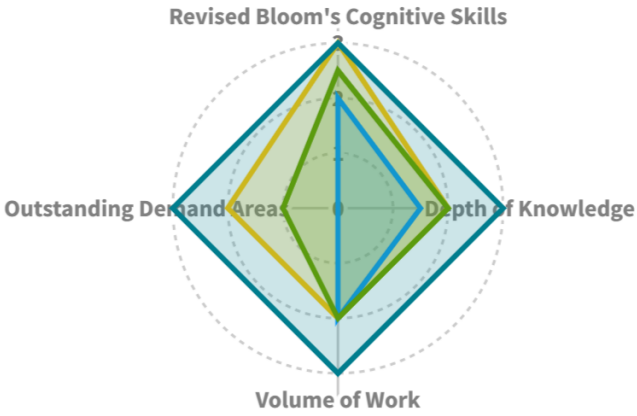

**OSSD grade 11 biology**




**OSSD grade 12 biology**




**DP and OSSD biology**



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.
  - A score of 2 was awarded to OSSD grade 11 biology due to the course's solid emphasis on evaluations and investigation, but only limited presence of creation-focused learning outcomes. For grade 12 biology, though a considerable number of learning outcomes still focused on application, a more substantial focus on analysis of information and data was observed, meriting a 2.5 Bloom's demand score.

- Regarding the score 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 HL topics pushed the score to a 3.
  - OSSD grade 11 biology was judged to merit a score of 1.5 due to the considerable detail and complexity of the material students are expected to study (including the expectation that students consider the ethical implications of science investigation) and pre-requisite knowledge from grade 10. OSSD grade 12 biology, in turn, was given a score of 2 as, although the primary focus of the course was still found to be on knowledge application rather than more complex reasoning, many topics were found to be studied in higher detail. The lack of clear opportunities for higher-order thinking prevented the course from achieving a score of 3.

- Regarding the scores for **Volume of Work**:
  - The 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.
  - For Ontario grade 11 and grade 12 biology, a score of 2 was awarded. Both courses were seen to include added depth of content (when compared to their pre-secondary counterparts) and although students only study six units of work, the number of themes and concepts covered was judged to be typical to high and the time allocation per topic was considered standard.

- Regarding the scores for **Outstanding Areas of Subject Demand**:
  - For the DP biology SL course (awarded a score of 2), the IA scientific investigation research project that students need to undertake, the linking questions outlined in the syllabus and the collaborative sciences project were considered to be areas of stretch. In addition to the latter, the HL course features additional higher-level topics which were deemed to include additional areas of stretch, meriting a score of 3.
  - For OSSD grade 11 biology no clear stretch areas were found. For grade 12 biology, the D1.2 research task (focused on analysis of key aspects of Canadian regulations pertaining to biotechnology and comparing to regulations from other jurisdictions) was judged to be a stretch area, awarding the course a score of 1 for this category.

# 6. Key Findings

This section summarises the alignment and main similarities and differences found between the DP and Ontario's upper-secondary programme (OSSD), both at programme level and subject level.

## 6.1 Programme Level

*Philosophical Underpinnings*

All the key themes within the IB's learner profile, ATL, and philosophy of international-mindedness are present to at least some extent in the OSSD philosophies on transferrable skills and cross-curricular and integrated learning. Although there are some differences in degree of emphasis on specific issues, students or teachers moving between the programmes would find a high level of consistency between the two.

*Programme Structure*

There are some similarities between the two programme structures; for example, both take a baccalaureate-style approach to encouraging breadth of study, both target completion of an overarching diploma while also providing subject-specific grades, and both include curricula components that sit alongside subjects (such as community activities).

However, there are significant structural dissimilarities that would make movement between the two programmes challenging for students in particular. The fact that the OSSD is four years in duration compared to the DP's two years is an important factor. Moreover, the number of curriculum components in each programme is quite different. The OSSD's 30-credit structure leads to a larger number of subjects being experienced by students, whereas the DP's six-subject structure leads to a smaller number of subjects. Additionally, the OSSD channels students into university/college/workplace subject streams, whereas the DP differentiates subjects as either SL or HL.

*Entry Requirements*

Both the DP and the OSSD present a flexible approach to entry requirements at the start of their programmes. The IB 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 for subjects in grade 9 in Ontario, though students' choices of what to study in subsequent grades are shaped by what they have successfully completed in each year. The subject-specific entry requirements in the OSSD are therefore cumulative across the four years of the programme, whereas the DP is highly flexible but generally fixes students into their subject choices for the whole two-year duration.

*Student Learning Pathways*

Both programmes provide a significant level of optionality in relation to subjects studied and both provide general guidance on what students can choose by directing them towards a balance of different subject groupings. The approach to combining subject-specialisation with breadth is therefore fairly similar; however, the structural dissimilarities mean that the practical nature of student pathways are inevitably quite different. The same student looking at both

programmes would have to make fairly different practical choices to achieve the specific subject balances required by each diploma, but both would enable that student to pursue subjects that interest them to a higher level than subjects that are less significant to their intended pathway.

*Assessment Methods*

Whereas the DP uses external terminal assessment to make up the majority of assessment in each individual subject, the OSSD does not make use of external assessment – instead, it uses flexible internal assessment to comprise the full weighting of assessment in all subjects.

Although this would seemingly make the two programmes weakly aligned, it should be noted that the flexibility of the internal assessment in the OSSD could result in a practical student experience that is quite similar in some respects to the DP's assessment patterns. Both programmes do use terminal assessment at the end of a period of study, along with coursework-style tasks in the duration of each course. Moreover, what little information is available on the OSSD's flexible assessment items indicates that similar question types to the DP would be likely – a mixture of multiple-choice, short, and long response questions, practical, performance, group, and independent research activities as appropriate to the subject in question.

The type of skills assessed in each programme and the weighting assigned to these also showed broad alignment.

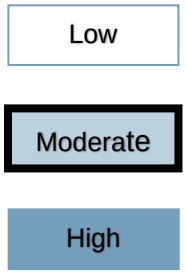
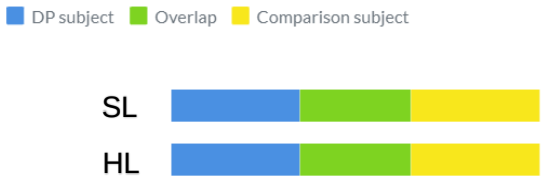
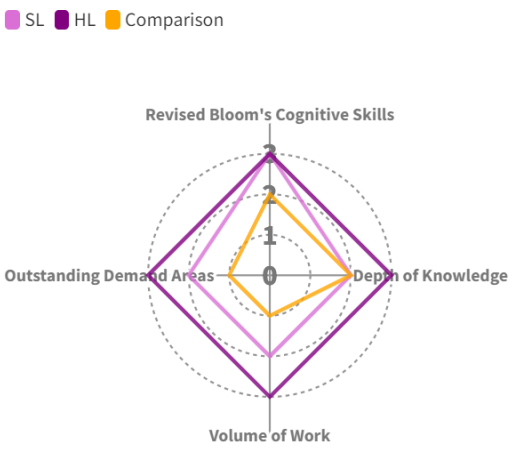
*Summary*

The structures of the two programmes are the most significant point of difference and the philosophical underpinnings are the most significant point of similarity. In all other respects, there are some notable differences, though with points of clear alignment with regards to how students would be likely to experience the programmes in practice.

## 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 OSSD. The summaries include key findings on learning outcomes alignment, content alignment and demand alignment, as per the key below:

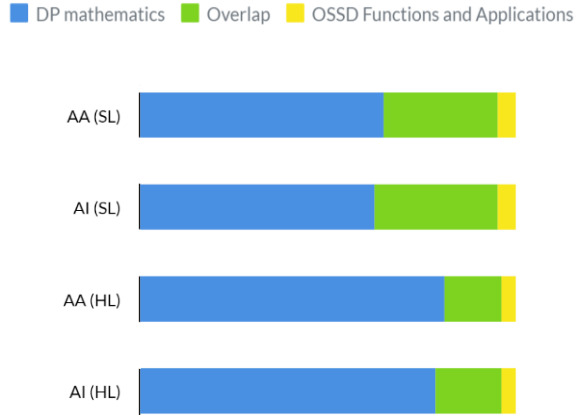
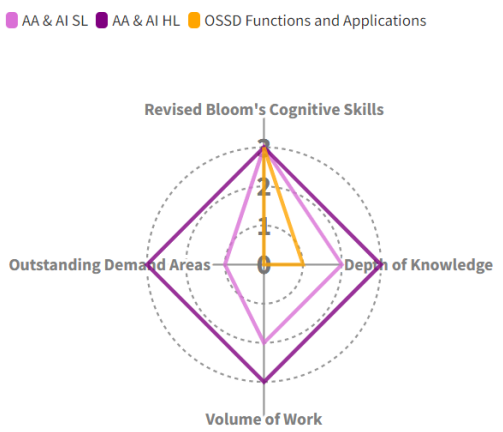
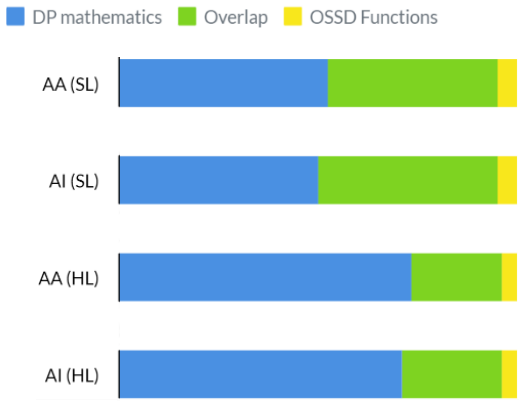
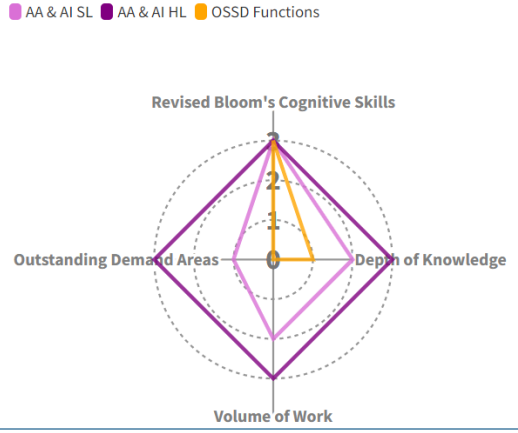
*Key:*

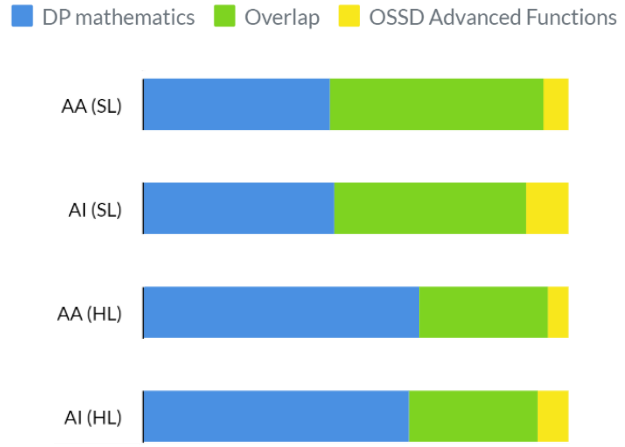
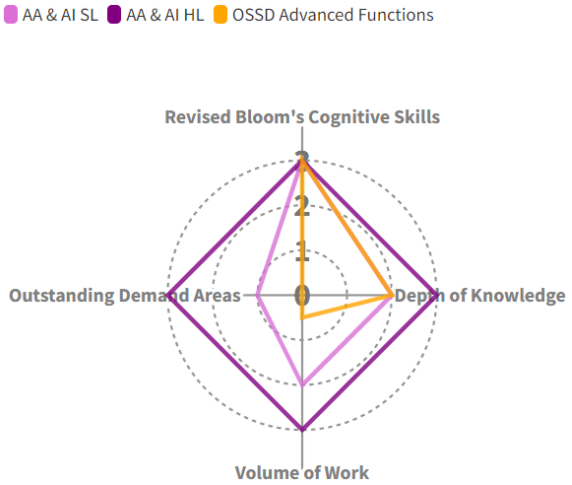
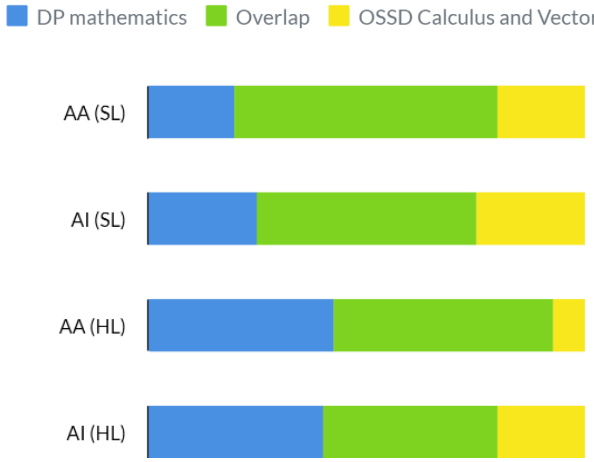
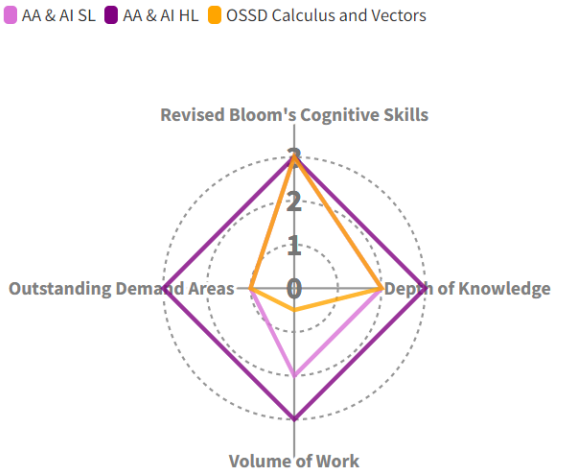
| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Displays the name of the comparison subject |  <br>This represents the learning outcome alignment between the DP subject and the comparison subject. A black border is placed around the selected judgement – '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 DP subject having more content unique to itself than the comparison did. A large green bar would indicate that a substantial proportion of content overlaps between the DP and the comparison subject. |  <br>This radar diagram displays the demand judgement scores for the comparison subject(s) and the DP subject – both SL and HL. |

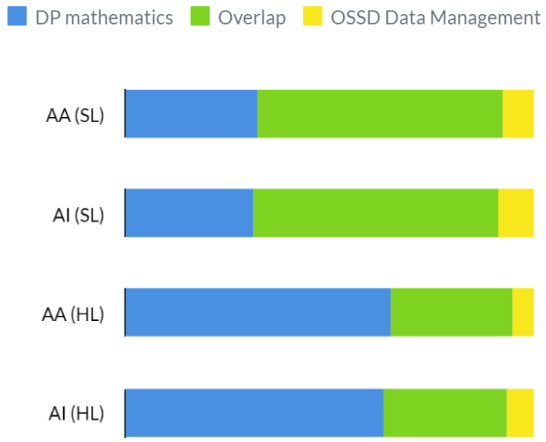
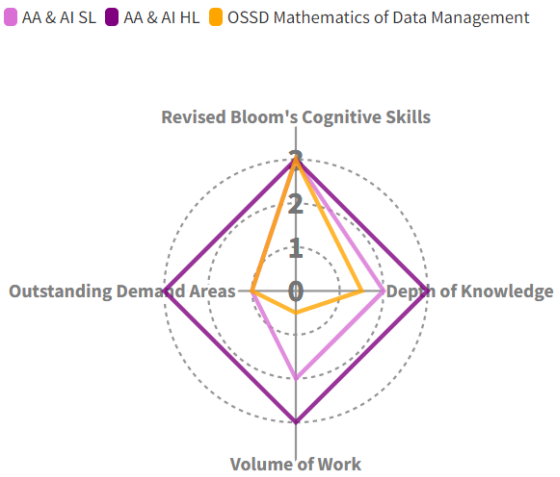
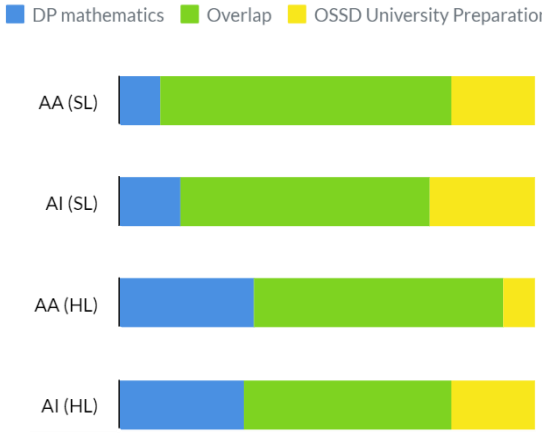
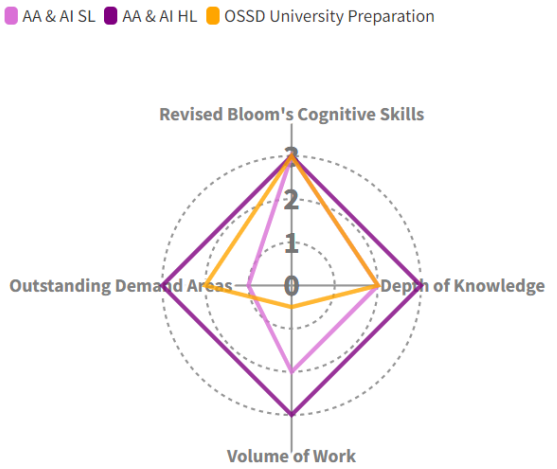
### 6.2.1 Mathematics Alignment

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

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

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 11 Functions and Applications (F & A) | Low<br>Moderate<br>**High** |  |  |
| Grade 11 Functions | Low<br>Moderate<br>**High** |  |  |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 12 Advanced Functions (AF) | Low<br>Moderate<br>**High** |  |  |
| Grade 12 Calculus and Vectors (CV) | Low<br>Moderate<br>**High** |  |  |

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Grade 12 Mathematics of Data Management (DM) | Low<br>Moderate<br>**High** |  |  |
| University Preparation (UP) | Low<br>Moderate<br>**High** |  |  |

- **Learning outcomes alignment**: the level of alignment between both DP mathematics subjects, at both SL and HL, and the OSSD courses' learning outcomes is significant, as all DP themes are present in the OSSD curricula.

- **Content alignment**: the level of content alignment between DP mathematics subjects and individual OSSD courses varies. For grade 11, alignment is generally low, as courses focus primarily on functions rather than a breadth of topics – it is not until grade 12, when further mathematical areas are offered for study, that more substantial alignment can be observed. Generally, there is considerable overlap with SL mathematics subjects, but limited overlap with HL subjects, except for where 'Calculus and Vectors' is studied or where a student takes all UP mathematics courses combined. Typically, and especially at HL, the DP contains more content than the OSSD comparison points.

- **Demand alignment**: DP mathematics courses, both at SL and HL, usually surpass the OSSD courses in demand level, especially those from grade 11. However, both 'Calculus and Vectors' and 'Data Management' score very similarly to DP SL for cognitive skills, depth of knowledge, and outstanding demand areas. All UP mathematics courses, taken as a whole, score similarly to DP SL for cognitive skills and depth of knowledge but score higher for outstanding areas of demand. For all OSSD courses, the main differences are with regard to volume of work, with the DP scoring significantly higher in this category.

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

- **Similarities in learning outcomes**: both the DP and OSSD set out general learning outcomes that are applicable to all mathematics courses within their programmes. All eight themes extracted from the DP are identifiable in the OSSD curricula, hence there is considerable overlap in mathematics learning outcome themes between the DP and OSSD. Not only are many of the same themes present, but they are also emphasised and described in very similar ways to the DP. The learning outcomes at grade 9, in particular, show higher similarity with the DP's due to additional expectations which describe in more detail transferable learning skills and wider contexts of mathematics – these additions have been introduced in a recent curriculum update and will likely be incorporated into other grades as they go through similar reviews.

- **Similarities in content**: each mathematics course available in the UP-strand correlates to one or multiple main topic areas studied in DP mathematics subjects. Generally, OSSD content is most similar to DP SL, though some AHL sub-topics are also covered to the same depth. Specifically for AA, there is strong alignment with the topics of 'Functions' and 'Geometry and trigonometry', as the UP courses, in combination, cover vectors in comparable detail and include a broad range of functions. As for AI, there is strong alignment in the topic of 'Functions' due to a similar focus on modelling within grade 11 Functions and grade 12 Advanced Functions. Content from the other DP topics of 'Number and algebra', 'Statistics and probability', and 'Calculus' can also be identified within UP courses, though the content covered is usually aligned with SL rather than HL. The similarity in content with DP curricula is

strongest when all UP courses are taken in combination, as only in this instance will each of the five main DP topics be studied. After this, the pathway with the strongest similarity is that of taking 'Calculus and Vectors', and its pre-requisites, as this enables study of four out of the five main DP content areas, as well as the study of the AHL topic of vectors.

- **Similarities in demand**: DP and OSSD both have the highest score for the presence of higher-order cognitive skills (taken from Bloom's Revised Taxonomy) and therefore have similar emphasis on analysis, evaluation, and creation in their learning outcomes. For the rest of the scores, OSSD has higher similarity with the demand level of the DP SL than the DP HL, with 'Calculus and Vectors' being the most closely aligned with SL, closely followed by other grade 12 courses.

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

- **Differences in learning outcomes:** though there is strong overlap in learning outcomes, the OSSD features slightly more emphasis on making connections within mathematics and creating a variety of representations. More notable differences occur in the new grade 9 curriculum with the introduction of 'Social-Emotional Learning Skills'. Although these overlap with some of the DP learning outcomes, they go further to encourage meta-cognition and self-regulation skills in mathematical learning. In contrast, the DP emphasises these skills primarily in a non-subject specific context – for example, through the IB learner profile.

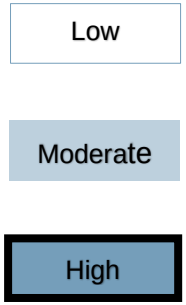
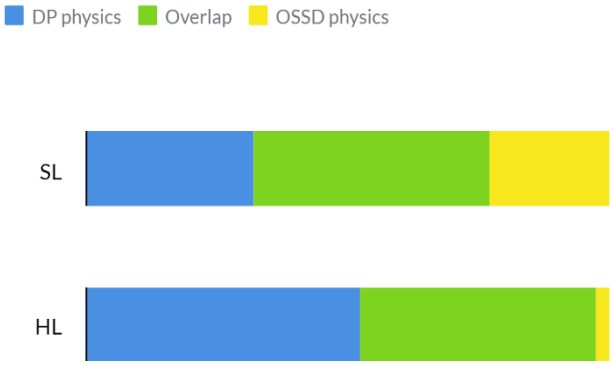
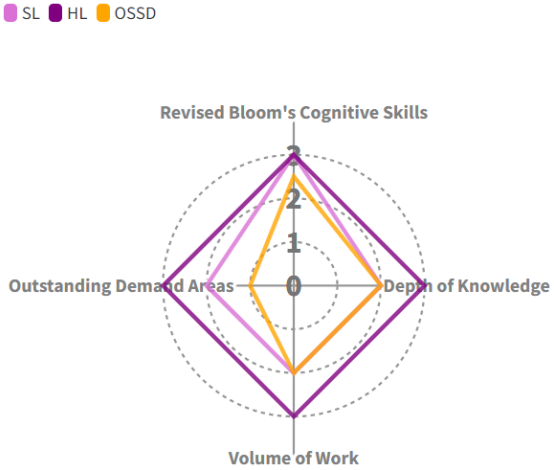
- **Differences in content:** there are various differences in mathematics content structure and alignment between the DP and OSSD mathematics. Notably, the UP courses in the OSSD focus on a narrow, rather than broad, range of main topics, while each DP mathematics course includes a substantially larger number of topics. Therefore, the breadth of topics covered in the OSSD largely depends on the number of courses taken, whereas all DP subjects offer breadth via five main topics to be studied in each. To cover a similar breadth of main topic areas as the DP, all grade 12 OSSD courses would need to be taken, though it is unclear from the documentation how common this is. Furthermore, in some topic areas, the OSSD does not include more typically advanced concepts. Instead, the OSSD content appears to focus on the 'why' and on making connections and comparisons to develop deeper conceptual understanding. For these reasons, OSSD content is largely different to DP HL mathematics, especially with regards to 'Number and algebra', 'Calculus', and 'Statistics and probability'. Overall, the OSSD curriculum has less instances of depth in topics than DP HL, and breadth of content is more variable than it is in DP subjects.

- **Differences in demand:** the most significant difference in demand between the OSSD and DP relates to volume of work. DP mathematics covers a greater number of different topics and complex concepts within the allocated teaching hours, whereas the OSSD allocates a generous amount of teaching hours to spend on one or two main topic areas. By also not including more advanced topics, the OSSD scores lower with regards to outstanding areas of demand, even where all UP courses are combined. Overall, OSSD UP as a pathway scores lower than DP HL subjects for demand.

### 6.2.2 Physics Alignment

The subject level alignment between the DP and OSSD physics is represented below:[90]

*Figure 34: Visual representations of subject-level alignment (physics)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Physics |   |   |   |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of DP and OSSD physics is significant, with all themes extracted from the DP learning outcomes being present in the OSSD's learning outcomes. While there are some small differences in focus – for example, the OSSD emphasising knowledge of Canadian contributions to science and making less explicit reference to scientific communication than the DP – the level of overlap is, nevertheless, substantial.

[90] For the purposes of simplicity, the summary visual includes the results from the comparison between the DP (SL and HL) and OSSD physics grades 11 and 12 combined. For specific information on the grade 11 course, refer back to section 5.

- **Content alignment**: there is reasonable topic and sub-topic overlap between DP and OSSD physics, for both SL and HL. Compared to SL, OSSD physics has slightly less content overall, though the latter does contain some sub-topics which are found in DP HL but not SL. As a result, OSSD physics also observes reasonable content overlap with HL, though the latter has more content overall, featuring a substantial amount of DP AHL physics content that is absent from OSSD physics.

- **Demand alignment**: OSSD physics has stronger alignment with the DP physics SL course, although it features fewer stretch areas than the latter. The DP HL significantly surpasses OSSD in demand level, featuring more stretch areas, greater depth of knowledge, and a higher volume of work.

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

- **Similarities in learning outcomes:** all the seven general learning outcome themes extracted from DP physics are present to some extent in all OSSD physics courses. In terms of emphasis on those themes, the OSSD is especially similar in its focus on developing technology skills, developing understanding and making connections, awareness of issues and the impact of science on the environment and society, creativity and critical thinking, and skills of scientific inquiry.

- **Similarities in content:** OSSD physics covers most of the topics in DP SL, to some extent. SL topics which OSSD physics has the strongest alignment with are currents and circuits, wave model, gravitational fields, motion in electromagnetic fields, and topics within 'Space, time and motion'. Other SL content is included, but in lesser detail. There are also a couple of partial alignments with AHL content involving special relativity, inductions, and quantum physics.

- **Similarities in demand:** the demand of OSSD courses varies significantly by grade (see key difference section below). Taken as a whole, the OSSD physics curriculum is closer to the DP physics SL course than the DP physics HL course, with the demand level of the HL being significantly higher. In particular, OSSD grade 12 physics scores for the cognitive skills, depth of knowledge, and volume of work demand categories mostly align with DP SL physics.

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

- **Differences in learning outcomes:** whilst Ontario similarly sets general outcomes for all sciences through its key science skills and goals, the curricula also have specific 'overall expectations' for each individual course between grade 9 and 12. When these are used to add context to the goals, it consistently emerges that courses tend to have some learning outcome themes which are not present in the DP, including a focus on Canadians' contributions to science, the recognition of indigenous peoples' knowledge and customs, and an explicit expectation that students understand the careers that study of science can relate/lead to. Furthermore, the emphasis on each theme varies per grade – OSSD science grades 9 and 10 have a more substantial focus on knowledge and understanding, while grades 11 and 12 physics observe a similar level of emphasis on higher order thinking skills as the DP physics course.

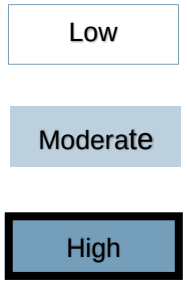
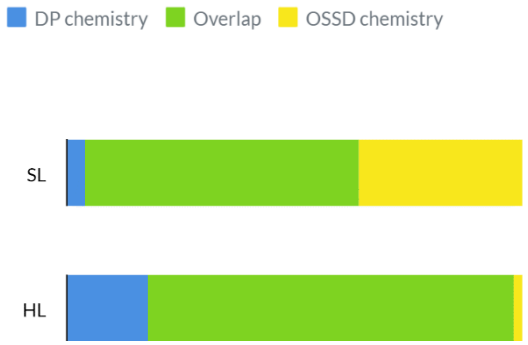
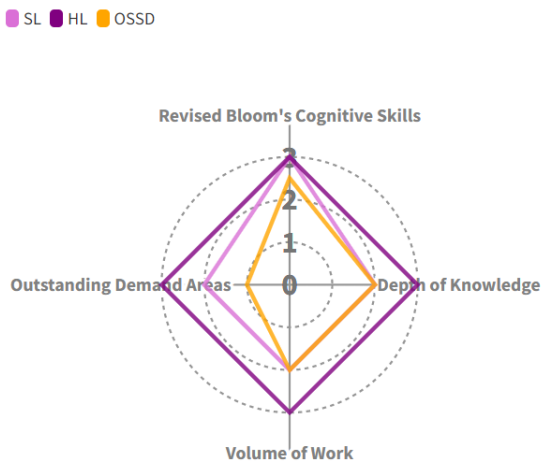
- **Differences in content:** one of the key differences between the OSSD and DP in relation to physics is that the OSSD programme includes two years of de-streamed general science before specialising in the third and fourth years. As a result, the grades 9-10 science curricula in Ontario have little in common with DP physics in terms of subject content, as only 25% of those courses are dedicated to physics. Taken as a whole, there is only partial alignment with SL and limited alignment with AHL content. Several SL topics are covered in lesser or different detail and the majority of DP AHL physics content is not present in the OSSD physics curriculum, including radioactive decay, electrical and magnetic fields, the Doppler effect, simple harmonic motion, thermodynamics, and gravitational fields. Therefore, OSSD physics has considerably less depth than DP HL physics.

- **Differences in demand:** the demand of OSSD courses varies significantly by grade, with science grades 9 and 10 observing, expectedly, low scores for demand across all categories, and grades 11 and 12 physics observing more similar scores to those of the DP physics SL and HL courses. Taken as a whole, the OSSD physics curriculum is closer to the DP physics SL course than the DP physics HL course, with the demand level of the HL being higher. This is mainly due to the outstanding demand areas score – the DP physics HL has a significantly higher number of stretch areas when compared to the OSSD courses.

### 6.2.3 Chemistry Alignment

The subject level alignment between the DP chemistry and OSSD chemistry is represented below: [91]

*Figure 35: Visual representations of subject-level alignment (chemistry)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Chemistry |   |   |   |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of DP and OSSD chemistry is judged to be high, as all themes extracted from the DP learning outcomes are present in the OSSD's learning outcomes. While there are some small differences in focus – for example, the OSSD emphasising knowledge of Canadian contributions to science and making less explicit reference to scientific communication than the DP – the level of overlap is, nevertheless, substantial.

[91] For the purposes of simplicity, the summary visual includes the results from the comparison between the DP (SL and HL) and OSSD chemistry grades 11 and 12 combined. For specific information on the grade 11 course, refer back to section 5.

- **Content alignment**: there is a large amount of topic and sub-topic overlap between DP and OSSD chemistry, for both SL and HL. DP SL has a small amount of content unique to itself, though the majority is shared with the OSSD. Compared to SL, OSSD chemistry contains more content unique to itself – these being sub-topics which are found in HL. Therefore, there is considerable alignment with DP HL chemistry overall, as a large proportion of AHL content is covered, as well as almost all SL content. However, the DP HL contains some additional content which is not in the OSSD.

- **Demand alignment**: OSSD chemistry has stronger alignment with the DP chemistry SL course, although it features fewer stretch areas than the latter. The DP HL significantly surpasses OSSD in demand level, featuring more stretch areas, greater depth of knowledge, and a higher volume of work.

The key similarities identified were the following:

- **Similarities in learning outcomes:** as with physics, all seven general learning outcome themes extracted from DP chemistry are present to some extent in all Ontario chemistry courses. In terms of emphasis on those themes, the OSSD is especially similar in its focus on developing technology skills, developing understanding and making connections, awareness of issues and the impact of science on the environment and society, creativity and critical thinking, and skills of scientific inquiry.

- **Similarities in content:** OSSD chemistry, as a whole, encompasses nearly all DP SL content and covers a significant amount of AHL content, therefore there is large overlap with HL overall. Topics which are covered in a similar level of detail as DP HL include electron configurations, classification of elements, energy cycles in reactions, the extent of chemical change, proton transfer reactions, and electron transfer reactions. Generally, the OSSD covers chemistry topics in similar detail to that of DP HL, thus there is a high level of alignment between the two.

- **Similarities in demand:** the demand of OSSD courses varies significantly by grade (see key difference section below). Taken as a whole, the OSSD chemistry curriculum is closer to the DP chemistry SL course than the DP chemistry HL course, with the demand level of the HL being higher. In particular, the OSSD grade 12 chemistry scores for Bloom's, depth of knowledge and volume of work demand categories mostly align with DP chemistry SL.

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

- **Differences in learning outcomes:** whilst Ontario similarly sets general outcomes for all sciences through its key science skills and goals, the curricula also have specific 'overall expectations' for each individual course between grade 9 and 12. When these are used to add context to the goals, it consistently emerges that courses tend to have some learning outcome themes which are not present in the DP, including a focus on Canadians' contributions to science, the recognition of indigenous peoples' knowledge and customs, and an explicit expectation that students understand the careers that study of science can relate/lead to. Furthermore, the emphasis on each theme varies

per grade – OSSD science grades 9 and 10 have a more substantial focus on knowledge and understanding, while grades 11 and 12 chemistry observe a similar level of emphasis on higher order thinking skills as the DP chemistry course.

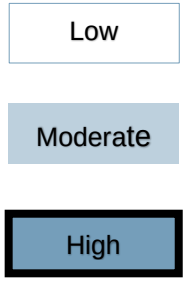
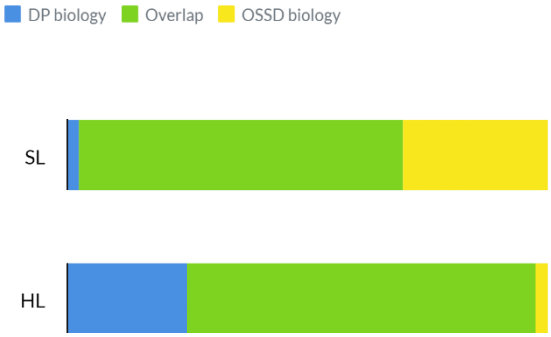
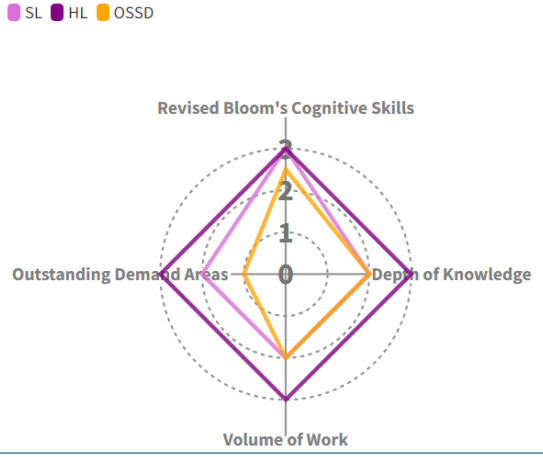
- **Differences in content:** as with other science courses, one of the key differences between the OSSD and DP in relation to chemistry is that the OSSD programme includes two years of de-streamed general science before specialising in the third and fourth years. As a result, the grades 9-10 science curricula in Ontario have little in common with DP chemistry in terms of subject content, as only 25% of those courses are dedicated to chemistry. Taken as a whole, while there is generally a high level of alignment between DP chemistry HL and the OSSD chemistry curriculum, there are a few HL sub-topics included within the DP curriculum which are not in the OSSD. These include the covalent model, classification of organic compounds, entropy and spontaneity, and the rate of chemical change.

- **Differences in demand:** as with physics, the demand of OSSD courses varies significantly by grade, with science grades 9 and 10 observing, expectedly, low scores for demand across all categories, and grades 11 and 12 chemistry observing more similar scores to those of the DP chemistry SL and HL courses. Taken as a whole, the OSSD chemistry curriculum is closer to the DP chemistry SL course than the DP chemistry HL course, with the demand level of the HL being higher. This is mainly due to the outstanding demand areas score – the DP chemistry HL has a significantly higher number of stretch areas when compared to the OSSD courses.

### 6.2.4 Biology Alignment

The subject level alignment between the DP biology and OSSD biology is represented below: [92]

*Figure 36: Visual representations of subject-level alignment (biology)*

| Subject name | Learning outcomes alignment | Content alignment | Demand alignment |
|---|---|---|---|
| Biology |   |   |   |

- **Learning outcomes alignment**: the level of alignment between the learning outcomes of DP and OSSD biology is high, with all themes extracted from the DP learning outcomes being present in the OSSD's learning outcomes. While there are some small differences in focus – for example, the OSSD emphasising knowledge of Canadian contributions to science and making less explicit reference to scientific communication than the DP – the level of overlap is, nevertheless, substantial.

[92] For the purposes of simplicity, the summary visual includes the results from the comparison between the DP (SL and HL) and OSSD biology grades 11 and 12 combined. For specific information on the grade 11 course, refer back to section 5.

- **Content alignment**: there is a large amount of topic and sub-topic overlap between DP and OSSD biology, for both SL and HL. DP SL has a small amount of content unique to itself, though the majority is shared with the OSSD. DP HL biology has a more significant amount of additional content, though again a considerable proportion is found in the OSSD. Generally, OSSD biology does not contain content which is not present in the DP syllabus.

- **Demand alignment**: OSSD biology has stronger alignment with the DP biology SL course, although it features fewer stretch areas than the latter. The DP HL significantly surpasses OSSD in demand level, featuring more stretch areas, greater depth of knowledge, and a higher volume of work.

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

- **Similarities in learning outcomes:** as with physics and chemistry, all seven learning outcome themes extracted from DP biology are present to some extent in all Ontario biology courses. In terms of emphasis on the themes, the OSSD is especially similar in its focus on developing technology skills, developing understanding and making connections, awareness of issues and the impact of science on the environment and society, creativity and critical thinking, and skills of scientific inquiry.

- **Similarities in content:** OSSD biology covers nearly all SL topics, and most with similar levels of detail. There is also AHL content covered in similar detail in the topics of nucleic acids, origins of cells, viruses, organelles and compartmentalization, cell respiration, and photosynthesis – plus other AHL topics which are covered in lesser detail. Therefore, there is some considerable alignment with DP HL biology content.

- **Similarities in demand:** the demand of OSSD courses varies significantly by grade (see key difference section below). Taken as a whole, the OSSD biology curriculum is closer to the DP biology SL course than the DP biology HL course, with the demand level of the HL being significantly higher. In particular, the OSSD grade 12 biology's scores for Bloom's, depth of knowledge, and volume of work demand categories mostly align with DP biology SL.

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

- **Differences in learning outcomes:** whilst Ontario similarly sets general outcomes for all sciences through its key science skills and goals, the curricula also have specific 'overall expectations' for each individual course between grade 9 and 12. When these are used to add context to the goals, it consistently emerges that courses tend to have some learning outcome themes which are not present in the DP, including a focus on Canadians' contributions to science, the recognition of indigenous peoples' knowledge and customs, and an explicit expectation that students understand the careers that study of science can relate/lead to. Furthermore, it can be noted that the emphasis on each theme varies per grade – OSSD science grades 9 and 10 have a more substantial focus on knowledge and understanding, while grades 11 and 12 biology observe a similar level of emphasis on higher order thinking skills as the DP biology course.

- **Differences in content:** as with other science courses, one of the key differences between the OSSD and DP in relation to biology is that the OSSD programme includes two years of de-streamed general science before specialising in the third and fourth years. As a result, the grades 9-10 science curricula in Ontario have little in common with DP biology in terms of subject content, as only 25% of those courses are dedicated to biology. Taken as a whole, while there is a considerable amount of alignment between DP biology HL and the OSSD biology curriculum, there are several AHL sub-topics included within the DP curriculum which exceed the OSSD in depth and complexity. These include proteins, membranes and membrane transport, cell specialisation, muscle and motility, enzymes and metabolism, chemical signalling, neural signalling, reproduction, homeostasis, natural selection, sustainability and change, and climate change. Overall, OSSD biology exceeds SL in depth of content, but does not contain enough AHL content (or other advanced material) to make it truly comparable to the depth of DP HL biology.

- **Differences in demand:** as with physics and chemistry above, the demand of OSSD courses varies significantly by grade, with science grades 9 and 10 observing, expectedly, low scores for demand across all categories, and grades 11 and 12 biology observing more similar scores to those of the DP biology SL and HL courses. Taken as a whole, the OSSD biology curriculum is more closely aligned with the DP biology SL course than the HL course, with the demand level of the HL being higher. As with the other sciences, this is mainly due to the outstanding demand areas score – the DP biology HL has a significantly higher number of stretch areas when compared to the OSSD courses.

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# 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 25: [Subject]*

| Demand Judgement | Score Descriptors (highlight the best-fit descriptor) | Judgement and Key Evidence |
|---|---|---|
| Revised Bloom's Cognitive Skills[93] | 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[94] | 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 | |

[93] Evidence pool: Learning outcomes
[94] 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[95] | 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[96] | 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) | |

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