# The International Baccalaureate Diploma Programme (DP): Alignment with Swedish Upper Secondary Education

Submitted to the International Baccalaureate by UK NARIC

The National Recognition Information Centre for the United Kingdom

The national agency responsible for providing information and expert opinion on qualifications and skills worldwide

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## List of Acronyms

| | |
|---|---|
| ATL | Approaches to Teaching and Learning - *IB* |
| CAS | Creativity, activity, service - *IB* |
| CP | Career-related Programme - *IB* |
| DP | Diploma Programme - *IB* |
| IB | International Baccalaureate - *IB* |
| MYP | Middle Years Programme - *IB* |
| PYP | Primary Years Programme - *IB* |
| TOK | Theory of Knowledge - *IB* |
| UK NARIC | The National Recognition Information Centre for the United Kingdom - *IB* |

# Executive Summary

The International Baccalaureate (IB) offers the Diploma Programme (DP) in many countries across the world, including Sweden. The purpose of this study was to identify similarities and differences between the IB DP and Swedish education system; and in particular to the Högskoleförberedande examen, the Swedish upper secondary qualification. The following questions guided the research and analysis:

1) To what extent does the Diploma Programme align with Swedish principles and general objectives for education[1]?

2) How do the principles, practices and standards of the DP compare with the overarching pedagogical and learning approaches, as well as the intended learning outcomes, for the Högskoleförberedande examen?

3) In what ways does the content and structure of DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL compare with equivalent Swedish upper secondary subjects?

4) In what ways do the DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL approaches to assessment align or differ with equivalent Swedish upper secondary subjects? Are there differences in the cognitive demand between DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL; and equivalent Swedish upper secondary schools?[2]

## Key findings

Overall, the IB education aligns very closely to the Swedish principles and general objectives for education (specifically, upper secondary education), in particular that both systems seek to:

- Provide students with a solid preparation for higher education or work.

- Support students' holistic, personal development and provide an education that builds not only knowledge, but social, communication, collaborative working and self-management and reflection skills.

[1] This would include reference to the Swedish Education Act 2011, and consider comparability in terms of the qualifications' commitment to "student personal development, the development of values (e.g. empathy and respect for human rights), active participation in society and the fostering of a lifelong desire to learn".

[2] One key methodology point: the Högskoleförberedande examen does not have centrally prescribed formal assessment. Therefore, the comparative analysis focussed on IB DP assessment objectives, assessment criteria and tasks drawn from past exam papers against the prescribed knowledge requirements for Grades A, C and E in the Swedish system.

- Provide an education that builds knowledge of human rights and democracy as well as the skills to function effectively within it, both in the classroom (through demonstrating respect for others, integrity, open-mindedness) and beyond (as active, responsible, tolerant and competent citizens).

- Develop learners who take responsibility for their own development and learning, both within their secondary studies and beyond, as enthusiastic lifelong learners.

Clear alignment can also be seen at a qualification level, in particular that the IB DP and Högskoleförberedande examen similarly acknowledge the:

- Importance of providing different options and/or pathways for students to reflect different aspirations, interests and abilities – the IB DP through its structure allowing students to select subjects at SL or HL and across different groups, and the Högskoleförberedande examen through its different national programmes.

- Importance of developing students' subject knowledge, critical thinking and independent study skills, cultural understanding and appreciation, communication, and reflection.

- Need to employ a range of tested teaching and learning strategies where the student is firmly at the centre and independent thinking and reflection; furthermore collaborative activities and activities linking learning to practical and real-world contexts are strongly encouraged.

- Individuality of the learner; the need to effectively monitor learner progress and understanding through formative assessment; and the importance of providing regular constructive feedback and adopting appropriate differentiation strategies.

Within the sciences, it was found that:

- Both the IB DP and Högskoleförberedande examen employ similar aims across the Biology, Chemistry and Physics courses, namely for students to develop key subject knowledge and skills, including practical and experimental skills. The utilisation of current research to support student curiosity and creativity is also a shared aim. Differences in the aims, where noted, were minor.

- The IB DP includes a wider coverage of science topics; likely a reflection of the different structure and number of courses within each programme. Nonetheless, many of the Högskoleförberedande examen topic areas can be similarly identified within the IB DP content curriculums within the three subjects examined.

- The learning outcomes for the IB DP and Högskoleförberedande examen science courses are similar, intending to develop students' knowledge and understanding of concepts and theories, and their ability to apply their knowledge and skills in a practical setting; emphasis is placed on conducting experiments and analysing their findings.

- Both qualifications have similar expectations for the science subjects on what students should be assessed on or be able to demonstrate. Both similarly require that practical skill are assessed and for students to be able to formulate hypotheses, conduct experiments, interpret and justify results and conclusions. Most importantly, there are similar expectations for students to demonstrate higher order thinking skills.

When comparing mathematics courses, the study found that:

- The IB DP mathematics courses examined (Mathematics HL and SL, and Mathematical Studies SL) employ similar aims to those in the Swedish mathematics courses with both focussing on developing students' knowledge, understanding and ability to apply their skills, and on challenging students to build their confidence in mathematics.

- Similar expectations are set across the learning outcomes for all of the IB and Swedish mathematics courses examined including for students to use mathematical concepts, formulate and solve problems with and without tools (i.e. calculators), apply mathematics to the real-world, understand its importance in other contexts and to communicate mathematically. The learning outcomes differ to a small extent, in that the IB DP Mathematical Studies SL places less focus on students' ability to design a mathematical model.

- Similar mathematics topics are covered between the IB and Swedish courses overall, including: problem solving, use of tools (i.e. calculators), application of mathematics to other subjects and problems related to cultural history of mathematics. On a course level:
  - IB DP Mathematics HL includes full coverage of content in the Swedish Mathematics 3c, 4 and 5 courses;
  - IB DP Mathematics SL includes many similar topics to HL and therefore has similar coverage of the Swedish Mathematics 3c, but fewer topics in common with Mathematics 4 and 5;
  - IB DP Mathematical Studies SL shares few topics with the Swedish courses and compares to a lesser extent overall with the Swedish mathematics courses examined in this study.

- In regards to assessment methods and cognitive demand, both programmes set similar expectations for students to be able to demonstrate knowledge of key concepts problem-solving, mathematical reasoning, mathematical models and use of digital tools within their assessments. The minimum requirements set to pass the Swedish mathematics courses are similarly assessed in the IB DP mathematics courses; the top Swedish grade includes similar expectations as those for a high mark in the IB DP internal assessments (i.e. a high level of accuracy and completion of mathematical processes with no errors).

Overall, the study has found clear and substantial similarities between the IB DP and the Högskoleförberedande examen, both in terms of their underpinning philosophies and the recommended learning approaches. The aims of the programmes are broadly similar and

whilst some differences in the content areas covered were noted, the IB DP nonetheless covers a significant proportion of the Swedish content and additional IB DP subject content that is valuable to the subjects taught. Further, the IB DP assessments demonstrate similar knowledge expectations to the Swedish subjects. This would indicate that IB World Schools in Sweden would be well equipped to deliver the IB DP in a way that is compatible with the overarching aims, goals, curriculum and assessment expectations of the Swedish system.



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# Introduction

## 1.1 Context and Scope

UK NARIC[3] was commissioned by the International Baccalaureate (IB)[4] to provide a holistic comparison of the IB Diploma Programme (DP) in the context of the Swedish education system. The DP is one of four programmes[5] offered by the IB across the world, including Sweden. As of December 2017, 39 schools in Sweden offer IB programmes, out of which 31 deliver the IB DP.

The main focus of the study is on identifying the similarities and differences between the IB and Swedish education system with regard to the philosophical underpinnings of education at upper secondary level (including aims, objectives and policies) and the resulting qualification design (including: content, structure, assessment methods and cognitive demand). Specifically, the study is designed around the following research questions:

1) To what extent does the Diploma Programme align with Swedish principles and general objectives for education[6]?

2) How do the principles, practices and standards of the DP compare with the overarching pedagogical and learning approaches, as well as the intended learning outcomes, for the Högskoleförberedande examen?

3) In what ways does the content and structure of DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL compare with equivalent Swedish upper secondary subjects?

4) In what ways do the DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL approaches to assessment align or differ with equivalent Swedish upper secondary subjects? Are there differences in the cognitive demand between DP Mathematics SL and HL, Mathematical Studies SL

[3] UK NARIC is the UK's national recognition agency for providing information and guidance on academic, vocational and professional skills and qualifications from all over the world. It has over 20 years' experience in researching, evaluating and comparing international qualifications and education systems to support and inform stakeholder understanding and recognition. More information on UK NARIC can be found in Appendix 1.

[4] The International Baccalaureate (IB) is a non-profit educational foundation founded in 1968. The IB is run internationally by four Global Centres in The Hague, Washington DC, Cardiff and Singapore. A Foundation Office is located in Geneva, and assessment is managed by the IB Global Centre in Cardiff.

[5] The others are the Primary Years Programme (PYP) – delivered to students between the ages of 3-12 and consisting of a written curriculum (what students should learn), a taught curriculum (how students should learn), and how to determine what students have learned (assessed curriculum); the Middle Years Programme (MYP) – offered to students aged 11-16 and including eight subject groups from which students choose their courses and an interdisciplinary unit; and the Career-related Programme (CP) – a two-year programme offered to students between the ages of 16-19 that intends to provide students with transferable and lifelong skills and competences in preparation for further or higher education, apprenticeships or employment.

[6] This would include reference to the Swedish Education Act 2011, and consider comparability in terms of the qualifications' commitment to "student personal development, the development of values (e.g. empathy and respect for human rights), active participation in society and the fostering of a lifelong desire to learn".

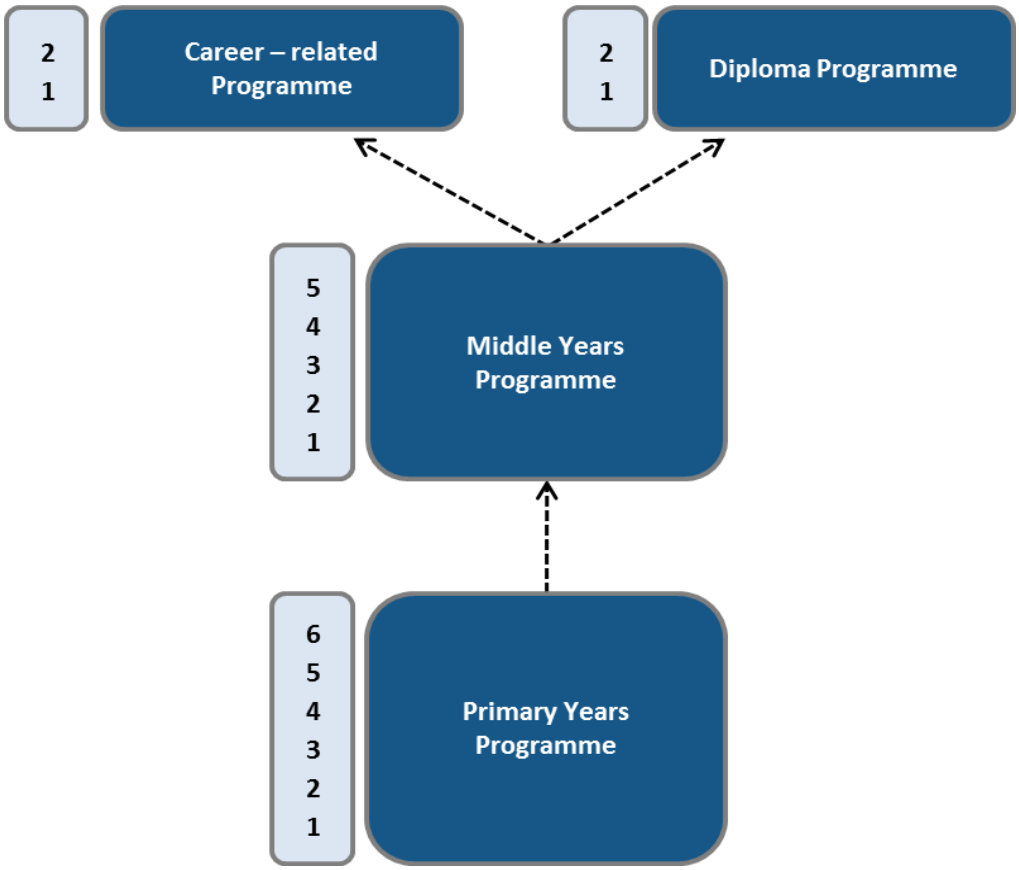
and Sciences (Biology, Chemistry and Physics) SL; and equivalent Swedish upper secondary schools?

Brief overviews of both systems are provided below to help contextualise the subsequent comparative analysis and findings.

### 1.1.1 The IB Diploma Programme

The IB DP is a two-year programme offered to students between the ages of 16-19 in authorised schools, referred to as IB World Schools. The IB World Schools can deliver any of the four individual IB programmes or offer them as a continuum. When taken as a continuum, the progression of the IB programmes can be seen in the figure below. Equally, students can enter any of the below IB programmes without previous experience in an IB programme.

**Figure 1: Progression of the IB programmes**



Schools offering the IB programmes are expected to assist students to become IB Learners. The IB Learner Profile sets out the academic and non-academic attributes which all IB programmes are designed to develop, namely that the IB Learners are[7]:

- Inquirers
- Knowledgeable
- Thinkers
- Communicators
- Principled
- Open-minded
- Caring
- Risk-takers
- Balanced
- Reflective.

No entry requirements are set for the IB DP, as students can come from the IB MYP and/or other qualifications or prior study. For some, but not all, students, the DP may be their first exit qualification for secondary school.

Students of the full DP study six courses chosen from the following subject groups:

**Table 1: IB DP Programme subject groups**

| IB DP Subject Groups[8] |
|---|
| • Language and Literature<br>• Language Acquisition<br>• Individuals and Societies<br>• Sciences<br>• Mathematics<br>• The Arts. |

Most subjects are offered at both higher level (HL) and standard level (SL), and students must take a combination of subjects from both levels, with three or four at HL. The HL subjects are studied in greater depth and breadth than those at SL and with more teaching hours (240 hours for HL and 150 for SL).

Their subject studies are complemented by the DP core, which incorporates:

- A theory of knowledge course (TOK) that allows for reflection on learning in all subjects
- An extended essay of 4,000 words on a topic of interest researched independently
- 'Creativity, activity, service' (CAS) – a student project on the CAS concepts.

[7] For the full IB Learner Profile, please visit: http://www.ibo.org/contentassets/fd82f70643ef4086b7d3f292cc214962/learner-profile-en.pdf

[8] Students may opt to study an additional Science, Individuals and Societies, or languages course, instead of a course in the Arts.

There is an option for students who are not enrolled in a full DP to take individual DP courses and assessment in order to receive a Diploma Programme Course result (DPCR). A DPCR can also be awarded to full DP students who do not meet the minimum requirements for a full DP.

All IB DP courses are assessed through a combination of external and internal assessment. Internal assessment is nonetheless to be based on guidance from the IB which typically covers: the purpose of internal assessment; general expectations on the role and responsibilities of the student and teacher in conducting the assessment; guidelines on acceptable uses of group work, where applicable; recommended time allocation; and assessment criteria with accompanying marks and achievement level descriptors.
Students receive marks for each assessment that are combined for a final grade in each DP course. These grades range from 7 to 1 (7 is the highest score). The results of each course are combined for a total score in the DP. To receive the full DP students must achieve a minimum of 24 points in addition to successful completion of the DP core.

### 1.1.2 The Swedish Upper Secondary School System

The Högskoleförberedande examen is a three-year upper secondary post-compulsory qualification designed to prepare students, typically aged 16-19, for higher education study. There are currently six higher education preparatory programmes, each designed to prepare students for a different area of undergraduate study.

Admission is based on student grades in their preceding studies, with subject tests in Year 9, the end of compulsory schooling. To undertake a higher education preparatory programme (högskoleförberedande examen), students should have passing grades in Swedish or Swedish as a Second Language, English, mathematics and at least nine other subjects. Subject-specific requirements may additionally apply for admission to certain national programmes. A range of national vocational programmes (*yrkesprogram*) are alternatively available for those looking to prepare for employment, with fewer subject passes required for admission (pass grades in Swedish, English, mathematics and at least five other subjects are required).

The national programmes are:

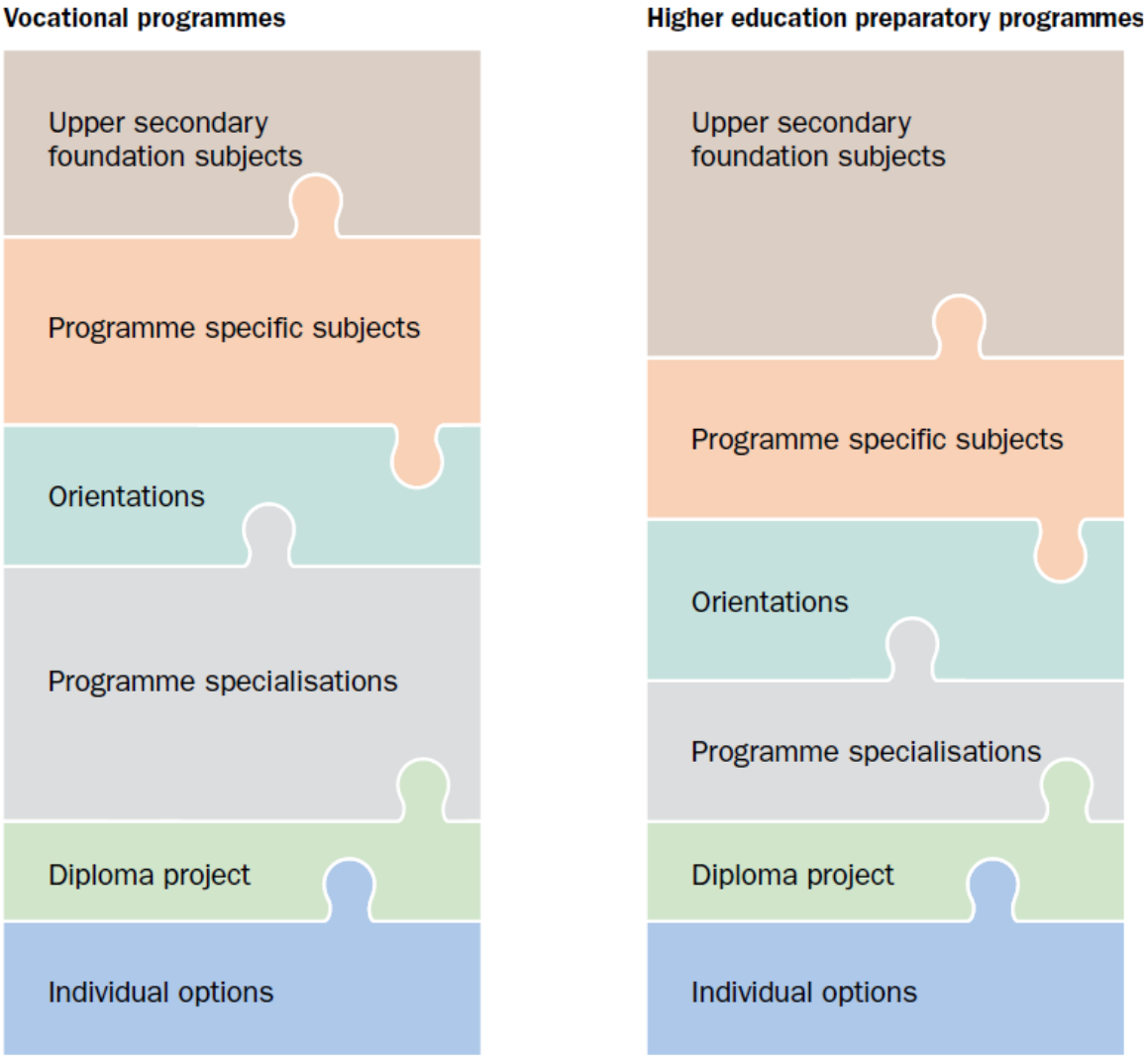
**Table 2: Swedish national programmes in upper secondary education (Skolverket, 2012)**

| Higher education preparatory programmes | Vocational programmes |
|---|---|
| • Arts Programme<br>• Business Management and Economics Programme<br>• Humanities Programme<br>• Natural Science Programme<br>• Social Science Programme<br>• Technology Programme. | • Building and Construction Programme<br>• Business and Administration Programme<br>• Child and Recreation Programme<br>• Electricity and Energy Programme<br>• Handicraft Programme<br>• Health and Social Care Programme<br>• Hotel and Tourism Programme<br>• HVAC and Property Maintenance |

| | |
|---|---|
| | Programme<br>• Industrial Technology Programme<br>• Natural Resource Use Programme<br>• Restaurant Management and Food Programme<br>• Vehicle and Transport Programme. |

These programmes comprise a minimum of 2,180 hours (60 minute teaching hours). Structurally the upper secondary programmes can be presented as follows:

**Figure 2: Structure of the Swedish upper secondary programmes**




**Source: Upper Secondary School 2011 (Skolverket, 2012)**

The foundation subject areas – English, history, physical education and health; science studies, religion, social studies, Swedish or Swedish as a second language; and mathematics – are common to all Högskoleförberedande examen programmes though the specific courses underneath these may vary. Other subject courses taken will depend on the programme and student's choice from a selection of approved orientations and

specialisations. As this also shows, students in the Swedish upper secondary system undertake a diploma project where the student poses their own question and produces an investigation of that question accompanied by a short summary of the work in English. The precise format of the project can vary between the different higher education preparatory programmes although a written report is typical. In all cases, the project is intended to test skills such as the students':

- Understanding of the subject matter
- Ability to develop a project plan, follow it and revise it as necessary
- Work independently whilst maintaining discussion with their teacher on the project[9]
- Reflect on the study and its findings including any limitations noted and a critical evaluation of the sources used.

Educational goals and the curriculum are centrally defined by the Swedish parliament (Riksdagen) and National Agency for Education (Skolverket) respectively, but education is largely decentralised in Sweden with municipalities responsible for organising schooling from pre-school to the end of upper secondary level. This decentralisation extends to assessment, with assessment designed, administered and marked at school-level meaning there is no common or prescribed format for this assessment. Teachers are required to grade students in relation to centrally defined knowledge requirements for each subject at grades A, C, and E. A general (non-subject specific) overview of A-E grade requirements is provided in the table below:

**Table 3: General grade descriptions for Swedish upper secondary school assessment (Skolverket, 2017)**

| Grade | Description |
|---|---|
| A | means the student has achieved all parts of the knowledge requirement for grade A |
| B | means the student has met all parts of the knowledge requirement for grade C and considerable share of the knowledge requirement for grade A |
| C | means that the student has achieved all parts of the knowledge requirement for grade C |
| D | means that the student has met all parts of the knowledge requirement for grade E and a considerable share of the knowledge requirement for grade C |
| E | means that the student has achieved all parts of the knowledge requirement for grade E |
| F | means that the student has failed to achieve any or all parts of the knowledge requirement for grade E. |

## 1.2 Structure of the Report

Section 2 of the report outlines the methodology used to complete the study. Section 3 then provides the main findings of the comparative analysis; these are structured to address each research question. Section 4 presents in brief the conclusions of the study, summarising the key points and any limitations of the study. The references cited within the report are provided in Section 5.

[9] It should be noted that the project itself can be completed individually or as a group however students are assessed individually based on their own role and work.

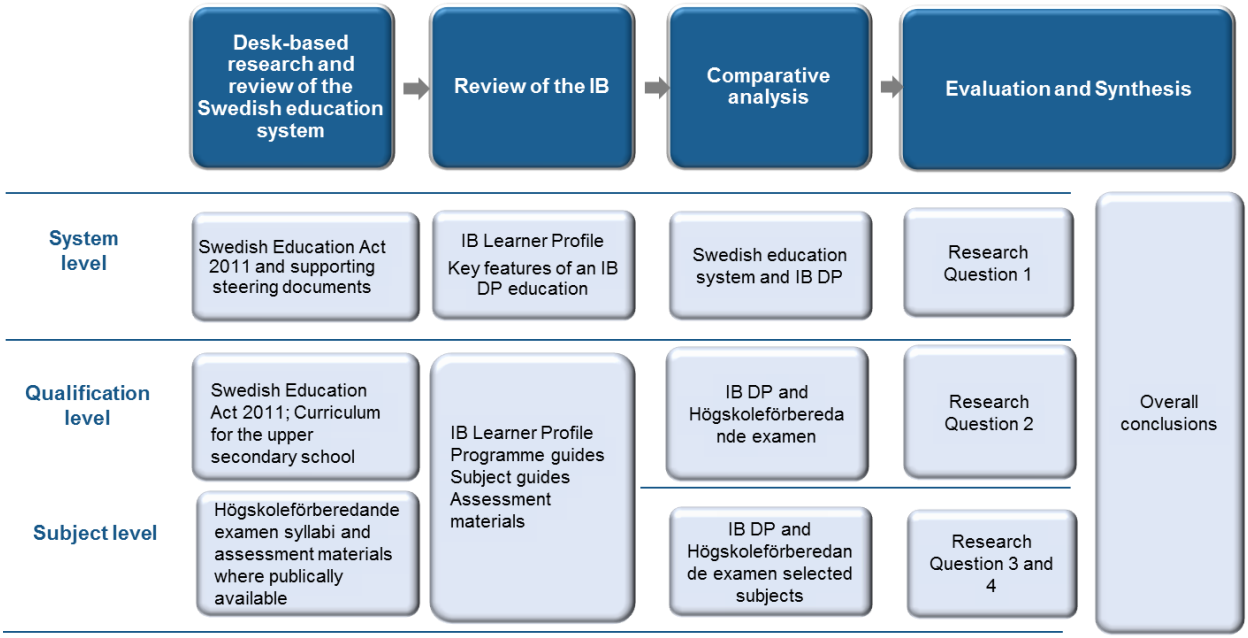
# 2. Methodology

To address the research questions and conduct a reliable comparison of the IB qualifications against the previously identified focal points in the Swedish education system, the study included three key phases:

- Desk-based research and document review:
  - For the Swedish school system
  - For the IB DP
- Comparative analysis
- Evaluation and synthesis.

The process can be illustrated as follows:

**Figure 3: Methodological process**




## 2.1 Desk-based research and document review

This stage involved firstly collating information pertaining to the IB DP, including the programme content, structure, assessment methods, learning outcomes and the educational philosophy, aims and objectives that underpin it. Similar information was also gathered on the Swedish school system, as available in the public domain. This included the Högskoleförberedande examen subject specifications and curriculum documentation. The Swedish Education Act 2011, Upper Secondary School 2011 overarching commentary, and the Curriculum for the Upper Secondary School were used to identify the underpinning philosophies, overarching goals and programme-specific intended learning outcomes, and the pedagogical approaches advised.

A full list of the sources cited within the report can be found in Section 5.

Next, the project team conducted a review of the education policies and goals, alongside curriculum and programmes as a whole, to contextualise the review of the IB DP and Högskoleförberedande examen subject specifications and inform any methodological considerations.

For Research Questions 1 and 2, the analysis centred on the Swedish Education Act 2011 and relevant policy and curriculum documents: the policy documents published by Swedish Parliament and the National Agency for Education are designed to be used collectively, so that it is possible for teachers, schools and other stakeholders to gain a thorough understanding of the goals for students to reach by the end of their upper secondary school studies.

A second, comprehensive qualitative analysis was undertaken to code emerging themes in the Swedish upper secondary system in preparation for the subsequent comparative analysis. For example, overall goals and guidelines are set out in terms of areas such as Knowledge; Norms and Values; Responsibility and Influence of Students: review and coding of the goals in each area found the themes to be Knowledge and Critical Thinking; Democracy and Citizenship; Cultural Understanding and Appreciation; Reflection and Personal Development.

## 2.2 Comparative analysis

The second stage of the project, the comparative analysis, comprised three tiers as shown in Figure 3:

- System level analysis: comparison of the IB DP aims and underpinning philosophies with key objectives for the Swedish school system as set out in the Swedish Education Act 2011 and supporting steering documents
- Qualification level analysis: comparison of the IB DP principles, practices and standards with the pedagogical and learning approaches, and the intended learning outcomes for the Swedish upper secondary school education (Högskoleförberedande examen)
- Subject level analysis: comparison of the IB DP curriculum and assessment, in particular to:
    - Compare the IB DP content, structure and intended learning outcomes with the Högskoleförberedande examen in selected mathematics, biology, chemistry and physics subjects.
    - Compare the IB DP assessment methods with the Högskoleförberedande examen.

The overall focus of the comparative analysis was on identifying the extent to which the salient principles and features of the Swedish upper secondary school education (Högskoleförberedande examen) identified within the preceding stage (described in 2.1), were evident within the IB DP, being mindful of inevitable variations in terminology.

### 2.2.1 System and qualification-level analysis [Research Questions 1 and 2]

As outlined above, the comparative analysis began with the system-level analysis, comparing the philosophical underpinnings of the IB and Swedish school education, since the principles and goals established at a national / overarching level should be reflected in the national school curriculum and assessment. This referenced the salient themes of the Swedish system identified during the review, presenting them in the following format:

**✔ Key theme 1**
**✔ Key theme 2…**

These are accompanied by supporting detail on the Swedish system. Using these themes as the benchmark, the project team then reviewed the IB DP materials to identify any similar themes, thus determining whether the IB DP was aligned to the Swedish upper secondary system.

In doing so, the report intends to provide a transparent yet concise comparative analysis of the Swedish and IB upper secondary school goals, learning outcomes and approaches.

The expected knowledge, skills and competences of the Swedish upper secondary school system are, to some extent, discussed within the comparison of overall goals. Nevertheless, the intended learning outcomes are briefly explored and compared by looking at the outcomes specified for one of the Högskoleförberedande examen programmes, the Natural Science Programme. This programme was chosen for its focus on sciences and mathematics, the subjects under analysis for Research Question 3 and 4.

For the IB DP, reference has been made to documents such as:

- Diploma Programme: From principles into practice
- Diploma Programme assessment: principles and practice
- Approaches to teaching and learning in the Diploma Programme
- Programme Standards and Practices.

### 2.2.2 Subject level analysis [Research Question 3 and 4]

As outlined in the Introduction, analysis of the IB DP against the Högskoleförberedande examen centred on the five subjects chosen by the IB: Mathematics (SL and HL), Mathematical Studies (SL), Biology (SL), Chemistry (SL), and Physics (SL).

The analysis identified and compared the Högskoleförberedande examen and IB, for each subject, in terms of aims, learning outcomes and goals, structure and content, assessment methods and demand. No judgement of quality is made or intended on the programmes.

The findings of this comparative analysis were documented in tabular format, so that where sufficient evidence of similarity/alignment was found between the IB DP and the Swedish system, a check mark (✓) was used. Where any aspect of the Swedish system was not considered to be included within the IB, the cell was left blank and further explanation provided below the table. If there was evidence to show that the IB can be considered

*partially* similar, a check mark with an asterisk was used (✓*). An example of the table format can be seen below:

**Table 4: Example mapping table**

| [Reference Point in the Swedish System] | Included in the IB |
|---|---|
| *Key theme 1* | ✓* |
| *Key theme 2* | |
| *Key theme 3* | ✓ |
| *Key theme 4* | ✓ |
| *Key theme 5* | ✓ |
| *Key theme 6* | |

For each table, a supporting analysis is provided to ensure transparency in the decision-making process. Any relevant key features or components of the IB which were not similarly found within the Swedish upper secondary school system reference points were also identified within the text, where appropriate.

The table below identifies the syllabi used as the basis for comparison.

**Table 5: Syllabi reviewed**

| Subject | Högskoleförberedande examen | IB DP |
|---|---|---|
| **Mathematics** | Mathematics 3c; Mathematics 4; Mathematics 5 | Mathematics HL and SL |
| | Mathematics 3c; Mathematics 4; Mathematics 5 | Mathematical Studies SL |
| **Biology** | Biology 2 | Biology SL |
| **Chemistry** | Chemistry 2 | Chemistry SL |
| **Physics** | Physics 2 | Physics SL |

## Content and Structure (Research question 3)

For each subject, we reviewed the number and range of topics studied to determine and compare the general breadth and depth of the courses. The core topics studied were also compared using the mapping table (Table 4) demonstrated above.

The analysis also compared the recommended teaching hours of the course (as a proportion of the full qualification) where comparable data was identified.

The aims and intended learning outcomes[10] of the IB DP and Högskoleförberedande examen for the selected subjects were also compared in this section to inform the content and structure comparison.

[10] As neither the Högskoleförberedande examen nor the IB DP prescribes learning outcomes, these have been drawn from Högskoleförberedande examen Goals and key sections from the IB DP specification.

### Assessment methods and demand (Research question 4)

Assessment for the Högskoleförberedande examen is developed and delivered internally by individual schools in Sweden[11]. There is no prescribed (or recommended) format or structure (i.e. type, number, duration, etc.) for the assessment of the qualification or subjects. Therefore, the comparison of the IB DP assessment methods was conducted against the Swedish *Knowledge Requirements* set within the subject syllabi for each of the courses. The Swedish *Knowledge Requirements* identify the skills expected at Grade A, C and E. The example below demonstrates the requirements for a Grade E in Physics 2:

> *"Students give an account in basic terms of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these with some certainty to look for answers to issues, and to describe and exemplify the phenomena and relationships of physics. Based on some examples, students give an account in basic terms of how the models and theories of physics have been developed. Students also evaluate the validity and limitations of models in simple assessments. Students identify, analyse and solve simple problems in familiar situations with satisfactory results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate with some certainty their own issues. Students plan and carry out in consultation with the supervisor experiments and observations in a satisfactory way. In addition, students handle materials and equipment safely. Furthermore, students interpret their results, evaluate their methods in simple assessments and give the reasons for their conclusions with simple reasoning. Students discuss in basic terms issues concerning the importance of physics for the individual and society. In their discussions, students put forward simple arguments and give an account in basic terms of the consequences of some possible viewpoints. Students use with some certainty the language of science and adapt to some extent their communication to purpose and context. In addition, students use different types of sources and make simple assessments of the credibility and relevance of their sources and information. In consultation with the supervisor, students assess with some certainty their own ability and the requirements of the situation."* (Skolverket, n.d.).

The comparison focussed on establishing how the level, type and range of skills expected for each of the selected subjects compared between the Högskoleförberedande examen and the IB DP. Examples from the IB DP assessment tasks, assessment objectives, internal assessment criteria, course content or grade descriptors were used where appropriate.

### 2.2.3 Evaluation and synthesis

The final stage of the project involved drawing together the key findings and conclusions from the review and comparative analysis.

[11] Sample assessments to guide teachers on possible formats do exist but are not available in the public domain nor made available on request.

# 3. Findings

## 3.1 Research Question 1: Principles and General Objectives for Education

**To what extent does the Diploma Programme align with Swedish principles and general objectives for education, including student personal development, the development of values (e.g. empathy and respect for human rights), active participation in society and the fostering of a lifelong desire to learn?**

Education in Sweden is governed by the Swedish Parliament (Riksdag) Education Act (*Skollag* (2010:800)) which came into effect on 1st July 2011. This sets out the general provisions of the reformed school education. In reforming the system, it was intended that:

- Students should be well prepared for the next stage of work or study
- Everyone should reach the prescribed goals for upper secondary education
- Education should be equivalent
- Study paths and steering documents should be clear.

The Act, together with the supporting steering documents such as the upper secondary school ordinance (*Gymnasieförordning* (2010:2039)), the curriculum (Skolverket, 2013) and accompanying commentary (Skolverket, 2012), diploma goals and subject syllabi are intended to be used together. Reviewing these documents revealed a number of objectives and key principles for secondary education in Sweden, all of which are also integral to an IB DP education:

### ✔Education should suitably prepare students for the next stage of work or study

In the case of upper secondary school, the Education Act defines this as preparation for higher education study or for employment, based on regional and national skills requirements.

The IB DP aligns very closely with this principle, combining subject study that provides both a breadth and depth of subject knowledge with a core that specifically develops and assesses skills commonly associated with higher education preparedness, including: planning and conducting independent research, extended writing, presenting reasoned arguments, appropriately referencing sources and applying analytical and evaluative skills (IB DP Extended Essay); as well as a coherent approach to learning with the ability to reflect on one's own experiences, draw connections and understand different perspectives (IB DP Theory of Knowledge).

The IB DP is widely considered to provide a suitable preparation for higher education with a range of independent studies conducted into the outcomes of the IB DP for further study. For example, a study into the performance of IB DP students in UK higher education institutions found that holders have a higher probability of achieving a first class degree in a UK university degree than those entering with GCE A Levels, one of the national upper secondary qualifications in the UK (Higher Education Statistics Agency (HESA), 2016). Another a study on enrolment and outcomes at post-secondary institutions in the USA found

that the first-year retention rate of IB DP students was 98% and that IB DP holders had "notably higher 6-year graduation rates (83%) than the 2009 national average of 56%" (Bergeron, L., 2015).

The IB also maintains a list of university recognition policies of the DP which, at the time of writing this report, included over 1900 institutions across a wide range of countries (International Baccalaureate, 2017). In 2016, UK NARIC separately researched university acceptance of the IB DP for the purposes of undergraduate admission. Through a desk-based review of published admissions requirements of 25 international universities, all drawn from the Times Higher Education Top 100 universities 2016, it was found that all 25 accepted the IB DP for direct entry[12], and in some cases, IB DP students may be granted advanced standing (UK NARIC, 2016).

### ✔Education should develop both knowledge and values, aligned with the principal democratic values on which Swedish society is based

The Education Act defines that schools should base their activities on the fundamental values of democracy and human rights and ensure that all pupils embrace these values (Sveriges Riksdag, 2010). This principle encompasses many aspects:

> *"The inviolability of human life, individual freedom and integrity, the equal value of all people, equality between women and men, and solidarity between people are the values that the education should represent and impart. In accordance with the ethics borne by Christian tradition and Western humanism, this is to be achieved by nurturing in the individual a sense of justice, generosity, tolerance and responsibility."* (Skolverket, 2013)

The Education Act further discusses equality, in terms of *access* to education – all students, irrespective of their geographic, financial or social circumstances, should have equal access to education – and in terms of the education itself – all students should be provided with the opportunity to meet the expected learning outcomes.

In the context of the classroom, the concept of democracy means that students should be able to "have influence over their education and shall be encouraged to participate actively in continuing to develop it" (Skolverket, 2015; Sveriges Riksdag, 2010). It also means that students should have the opportunity to freely express their ideas and should feel respected (Sveriges Riksdag, 2010).

Teaching should build knowledge of these key concepts whilst also working to ensure democratic classrooms. This area – and the alignment of the IB DP through its development of open, democratic classrooms – is also discussed later in this section and under Research Question 2, section 3.2.

At an overarching level however, clear parallels can be seen between this underpinning philosophy of the Swedish system and that of the IB DP. In particular that the IB DP, and indeed all IB programmes, seek to develop a "Principled" learner, one who acts "with

[12] Subject to achievement of the institution's required grades.

integrity and honesty, with a strong sense of fairness and justice, and with respect for the dignity and rights of people everywhere". (International Baccalaureate, 2013a)

### ✔Education should promote the learning and development of all children, both accounting for the differing needs of children and promoting a desire for lifelong learning

As outlined above, the Education Act emphasises that *all* students should be given the opportunities to achieve the expected goals and to be given direction and motivation to learn and develop. Accordingly, it is recognised that education needs to account for differing needs and be able to recognise and cater for high performers and those with special needs. The Act and accompanying documents stipulate that the best interests of the learner should be the starting point for education.

This is very much aligned with a central idea of the IB education, that there are "students with their own learning styles, strengths and challenges…students come to school with combinations of unique and shared patterns of values, knowledge and experience of the world and their place in it" (International Baccalaureate, 2013a). Accordingly, the need to be able to understand and effectively cater for the diverse needs of students is acknowledged clearly across all IB materials for schools and teachers.

The ways in which this should happen in practice are discussed later in this report in relation to the specific pedagogical approaches associated with delivery of the IB DP and Högskoleförberedande examen (Section 3.2).

Also clear within the Education Act is the importance of fostering lifelong learners, those that want to and are capable of continuing and extending their learning beyond the classroom. This principle underpins an IB education, which "aims to inspire a lifelong quest for learning, hallmarked by enthusiasm…" (International Baccalaureate, 2013b), and is reflected in its Learner Profile: "Inquirers" nurture curiosity, develop skills for research and inquiry, "learn with enthusiasm and sustain our love of learning throughout life" (International Baccalaureate, 2013a).

### ✔Education should support students' development as active, creative, competent and responsible individuals and citizens

In both the Education Act, and further reiterated in the National Agency for Education, Skolverket's, commentary *Upper Secondary School 2011*, it is highlighted that upper secondary education should provide "a good foundation for…personal development and active participation in the life of society. The education should be organised so that it promotes a sense of social community and develops students' ability to independently and jointly with others acquire, deepen and apply knowledge" (Skolverket, 2012).

A central aim of the IB DP is that it provide a broad, balanced and holistic education to develop not only knowledge, understanding and skills across several academic disciplines but which also goes "beyond the acquisition of knowledge and skills to include the education

of the 'whole' person" (International Baccalaureate, 2015) encompassing the development of personal, emotional and social skills.

As part of this, "students also need to develop the "will to act" and the skills and values necessary to make a positive contribution to society. Responsible citizenship is based upon compassionate and well-informed citizens who become proactively involved in their communities. It is also important to encourage young people to enjoy life to the full, and educating the whole person includes exposure to artistic, recreational and sporting activities that can enrich experience (Peterson 2003:58)." (International Baccalaureate, 2015)

## 3.2 Research Question 2: Qualification Principles, Practices and Standards

### How do the principles, practices and standards of the DP compare with the overarching pedagogical and learning approaches, as well as the intended learning outcomes, for the 'Högskoleförberedande examen?

### 3.2.1 Intended learning outcomes

The *Curriculum for the Upper Secondary School* sets out the goals that all students should fulfil by completion of their upper secondary studies in Sweden. These goals are categorised into a number of areas, including:

- Knowledge
- Norms and values
- Student responsibility and influence
- Education choices
- Assessment and grades[13].

When examining the ways in which the goals compare, it is useful to draw out the key themes which occur across the different categories. The research team identified that the goals could be broadly grouped according to the following themes:

- Knowledge and critical thinking skills
- Democracy and citizenship
- Cultural understanding and appreciation
- Reflection and personal development.

#### ✔ Knowledge and critical thinking skills

Linked to the overarching principle that education should suitably prepare students for the next stage of further study or working life, the Curriculum states that, by the end of upper secondary school studies, students should have good knowledge in the courses studied and be able to use this knowledge for the purposes of further study, work or their everyday life. This is similarly a key intended outcome of the IB, with subject courses aiming to develop in-depth knowledge that would prepare them for higher level study in similar, related or wider fields. This reflects the IB Learner Profile, that the IB learners should be "Knowledgeable",

[13] Please note that goals are also defined at a programme- and at a subject- level and these are described and examined in the subject analyses (section 4.3). The goals discussed in this current section are a summarised and categorised version of the goals defined in *Curriculum for the Upper Secondary School* (Skolverket, 2013).

"Thinkers", "Inquirers"; able to think independently, critically, and work through complex problems. This is well reflected from the overarching IB Learner Profile through to the teaching and assessment of the IB DP and means that students of the IB DP should develop those skills valued by the Swedish upper secondary school system, such as the ability to "learn, explore and work independently...", to "critically examine and assess what they see, hear and read in order to be able to discuss and take a view on different issues concerning life and values" and to "use their knowledge as a tool to formulate, analyse, test assumptions and solve problems...". (Skolverket, 2013)

### ✔ Democracy and citizenship

By the end of upper secondary studies in Sweden, it is intended that students have developed both knowledge about democratic societal and working life and the skills to participate in it. The curriculum also states that they should be able to interact with people from diverse cultural, linguistic, religious and socio-economic backgrounds; to recognise and respect the value of others; and to care and show empathy for those both in their immediate environment and beyond. Students should also be able to take responsibility for working in democratic ways and to actively contribute to a deeper democracy in society.

These aspects are integral to the IB with many relevant attributes evident across the IB Learner Profile, noting that students should be "principled", acting with integrity and with respect for others; "caring" in that they should be able to show empathy, compassion and respect; "balanced", aware of their "interdependence with other people and with the world in which we live"; and "thinkers", able to make ethical decisions. Specifically, the Learner Profile sets out the IB's intention to develop a well-rounded, competent and active citizen.

Also under this theme in the Swedish upper secondary school system, is the intention that students are able to assess events from a Swedish, Nordic, European and global perspective. Whilst, as an international qualification, the IB does not specify these countries and regions, integral to the IB DP intended learning outcomes and learner attributes is the ability to reflect on different perspectives – the learner's own (local / national) and international perspectives noting that 'international mindedness' "starts with self-awareness and encompasses the individual and the local/national and cultural setting of the school as well as exploring wider global perspectives" (International Baccalaureate, 2015). In any case, IB DP World Schools in Sweden would have the flexibility to incorporate Swedish, Nordic and European perspectives to their teaching and learning approaches.

One intended learning outcome of the Swedish upper secondary school is that learners should be able to "observe and analyse the interaction between people in their surroundings from the perspective of sustainable development". (Skolverket, 2013)

### ✔ Cultural understanding and appreciation

When comparing the IB DP to the expected knowledge and understanding of culture in the Swedish upper secondary school system, several differences can be observed. For example on completion of Swedish upper secondary school, students should have knowledge of and insight into key aspects of Nordic, Swedish and Western cultural heritage; as well as

knowledge of the culture, history, language and religion of the different minorities in Sweden (Skolverket, 2013).

The IB DP, as an international qualification, does not explicitly develop knowledge and understanding of Swedish and Nordic heritage. That said the IB recognises that "each school is unique and needs to consider its own context and the community it serves…" (International Baccalaureate, 2015) and also stipulates that IB World Schools ensure that their written curriculum reflect the IB philosophy: this places considerable emphasis on intercultural understanding and international-mindedness, specifically to ensure that students are able to reflect on their own heritage and perspective, and on others, with an open attitude and cultivated curiosity about the world and the different cultures within it.

This is also supported through the compulsory language learning of the IB DP, as with the Swedish Högskoleförberedande examen which includes English as a core foundation subject across all its programmes (English 5 and 6) although the specific objectives of language and literature subjects have not been reviewed as part of this project.

The Swedish upper secondary goals that students should be able to "Use non-fiction, fiction and other forms of culture as a source of knowledge, insight and pleasure," and "Obtain stimulation from cultural experiences and develop a feeling for aesthetic values" (Skolverket, 2013), are broadly covered within the IB DP Language and Literature group courses, which seek to promote enjoyment of a range of texts, and an appreciation for their aesthetic qualities.

### ✔ Reflection and personal development

The Swedish curriculum states that, in making "choices for education, work and societal life" students should be aware of the opportunities for further education and work both in Sweden and overseas. This also reflects an expectation in the IB DP, which requires that schools offer guidance to students on post-secondary educational options, although guidance on work is not explicitly referenced.

The Swedish upper secondary school goals also place notable emphasis on developing confident learners who plan and take responsibility for their own studies or work, and can "use books, library resources and modern technology as a tool in the search for knowledge, communication, creativity and learning". They should be able to work independently on their own initiative as well as with others, and furthermore be able to reflect on their own results versus the requirements to assess their need for development.

The IB DP objectives therefore align very well to the goals set out for Swedish upper secondary school noting that "IB programmes promote the development of schools that: create educational opportunities that encourage healthy relationships, individual and shared responsibility and effective teamwork and collaboration;" (International Baccalaureate, 2013b) and that IB students, being "Inquirers" and "Reflective", should "know how to learn independently and with others" and "work to understand [our] strengths and weaknesses in order to support our learning and personal development" (International Baccalaureate, 2013a). The IB also stipulates that "library/multimedia/resources play a central role in the

implementation of the programme" (International Baccalaureate, 2014) which should support students in developing their research (knowledge development), communication, creativity and learning as expected in the Swedish system.

Also categorised under personal development for the purposes of this study, is that upper secondary school students in Sweden should have "knowledge about the preconditions for good health" (Skolverket, 2013). This is similarly reflected in the IB Learner Profile where being "Balanced" indicates that learners "understand the importance of balancing different aspects of [our] lives – intellectual, *physical*, and emotional – to achieve well-being…". (International Baccalaureate, 2013a)

One goal of the Swedish system not explicitly referenced in the IB DP is that on completion of upper secondary school, students "are aware that all professional areas are changing in relation to technological development, changes in society and professional life, and greater international interdependence, and thus understand the need for personal development in their working life" (Skolverket, 2013).

### Programme level learning outcomes

In addition to and drawn from the overarching Swedish upper secondary school learning outcomes, specific learning outcomes are set for each of the upper secondary school national programmes[14]. There are many shared intended outcomes across the different programmes; for example that the programme should develop the knowledge needed for higher education studies in relevant areas; analytical and creative thinking skills; and the ability to take responsibility for one's own development. The ways in which the IB DP aligns to these intended learning outcomes has been discussed above.

The intention of this sub-section is to provide a brief comparative analysis of the IB DP against the specific learning outcomes for the Swedish Natural Sciences Programme. The table below presents the overarching goals of the Swedish programme as well as those for the Swedish programme's integrated diploma project[15].

[14] A list of the national programmes can be found in Table 2, section 1.1.2.

[15] A diploma project is required in the Högskoleförberedande examen; the format between the different higher education preparatory programmes varies although a written report is typical. More information of the diploma project is provided in 1.1.2.

**Table 6: Learning outcomes / goals for the Högskoleförberedande examen Natural Sciences Programme**

| Högskoleförberedande examen Natural Science Programme | Högskoleförberedande examen Diploma Project |
|---|---|
| Students should develop:<br>• The knowledge needed for higher education studies primarily in the natural sciences, mathematics and technology, and in other areas<br>• Knowledge "about context in nature, about the conditions for life, about physical phenomena and events, and about chemical processes"<br>• An ability to think creatively and analytically<br>• A scientific approach, thinking critically, reasoning logically, solving problems and making systematic observations; able to assess different sources and "distinguish between statements based on scientific and non-scientific grounds"<br>• An understanding of sciences based on theoretical and practical study (e.g. Experiments, field studies)<br>• Understanding of historical ideas and theories of science whilst also having the opportunity to benefit from current research<br>• Understanding of the interaction of science and society and especially the role of science in sustainable development issues, with the opportunities to participate in ethical discussions on these areas<br>• Ability to communicate on science and mathematics verbally and in writing<br>• Ability to understand, read, write and discuss basic science in English<br>• Ability to search for, select, process and interpret information and learn about new technology<br>• Ability to take responsibility for their own development, to take initiative and explore ideas in practice. | Students should demonstrate:<br><u>Facts and understanding</u><br>• Relevant knowledge about the chosen knowledge area with a starting point in a specific idea or question<br>• Knowledge of relevant terms, theories, models and methods in the chosen knowledge area<br>• Knowledge of relevant sources and how their relevance and credibility can be assessed<br><u>Skills</u><br>• Skills in defining their starting questions<br>• Skills in using relevant concepts, theories, models and methods for handling their questions, such as using natural science or mathematical methods in work where simple or concrete experiments are the starting point<br>• Skills in using appropriate techniques and methods to search for and gather information, and process the material<br>• Skills in presenting results in a written report that fulfils the basic requirements of the genre in terms of language correctness and formal structures<br>• Skills in orally summarising and presenting diploma projects in a way that is adapted to the situation and the target group, and also<br>• Skills in briefly summarising results in written English in appropriate language<br><u>Assessment ability and approaches</u><br>• Take initiatives and responsibility for adapting planning and working methods to the situations and requirements that occur during the work<br>• Critically assess and work independently with selected sources and aesthetic expressions<br>• Assess and draw conclusions from their results based on their own intentions and choices of expressions, methods, technologies and sources, based on their own working methods and work input<br>• Give, consider and assess objective responses. |

Many similarities are observed between the Högskoleförberedande examen Natural Science Programme and the IB DP science courses (Biology SL, Chemistry SL, and Physics SL). The application of creativity, analysis, and communication skills in a scientific context and the use of technology are all aims shared between the courses as found within the IB DP science aims. Practical and experimental skills are also similarly emphasised, with both aiming for students to develop the ability to think critically, evaluate scientific information and statements, and make observations and conclusions; these are demonstrated not only in the IB DP science aims but also within the Assessment Objectives. Through these expectations, and the internally-assessed practical investigations, the IB DP similarly requires that students develop an understanding of both the theoretical and practical study of science.

The historical background of science is not a key aim in the IB DP, but the development of theories and an awareness of current research are integral to the IB DP *Nature of Science* and the overall curriculum. The interaction or application of science in society is partially shared with the IB DP, also from the *Nature of Science*; however the understanding of the ethical implications of science is a key aim in both programmes.

With regards to communication, including the communication of mathematics and using English, these are partially shared with the IB DP whilst acknowledging that the IB DP can be undertaken in languages other than English. Nonetheless, communication skills are similarly emphasised in both programmes, and the IB DP science courses require understanding and use of mathematics, but less emphasis is placed on verbal speaking skills within these science courses.

The Natural Science Programme goals also specify the key knowledge to be covered within the courses. The key findings of the comparative analysis of content for the science and mathematics courses in the IB DP and Högskoleförberedande examen is examined within the science comparative analyses in Sections 3.3.1-3.3.3.

The Diploma Project of the Högskoleförberedande examen Natural Science Programme “should demonstrate that students are prepared for studies in higher education, in the first instance in the natural science or mathematics area” (Skolverket, 2012). The knowledge, understanding, skills, and assessment ability on which the Swedish Diploma Project should be evaluated, are also well developed and assessed within the IB DP through a range of assessment methods. For example, the IB DP Extended Essay (part of the DP core) is designed to promote and assess students’ independent research and writing skills with students required to write a 4,000-word essay on an appropriate topic area. Students are expected to gather and select relevant material; present information clearly to demonstrate knowledge and understanding; and construct reasoned arguments based on critical thinking skills of analysis and evaluation. Within the science subjects themselves, there is both the Group 4 project, a collaborative interdisciplinary project in which students select a common topic or problem to analyse; and an internal assessment which provides scope for students to individually conduct a scientific investigation and write up their findings.

The need to summarise results in English (a language requirement for the Högskoleförberedande examen) is not explicitly relevant in the IB given that the mother tongue of its international cohort will vary, with many native and non-native English speakers but the goals for the Swedish Diploma Project are otherwise well met by the IB DP.

### 3.2.2 Pedagogical and learning approaches

To support and enable student achievement of the above learning outcomes, guidance on the role and approach of teachers and schools is defined by the Swedish National Agency. As noted in the Introduction to this report, education in Sweden is largely decentralised and the organisation and means through which curriculum, teaching and learning is delivered to fulfil the goals is determined at a local level: Each municipality creates a local school plan (*skolplan*) describing how the municipality intends to fulfil the national goals for the school. Each school, in consultation with the teachers and other staff, furthermore develops a local work plan (*lokal arbetsplan*) based on the national goals and the local school plan, which defines course content, organisation and teaching methods. Teaching staff decide what teaching material and method to use.

Through review of the guidelines for teachers set out in the *Curriculum for the Upper Secondary School* (Skolverket, 2013), linked to the goals for students [16], it can be summarised that teaching should:

#### ✔ Be objective and encompass a range of differing approaches

Specific approaches are not prescribed by the Swedish upper secondary system: the Education Act states that education should be "Based on scientific grounds and proven experience" (Sveriges Riksdag, 2010 as cited in Skolverket, 2014) although the implementation of this in practice may currently be ongoing as the upper secondary reforms are still relatively recent. Basing teaching on scientific grounds should mean working to "critically review, test and place individual facts in context" whilst 'proven experience' refers to the use of widely tested teaching strategies and approaches.

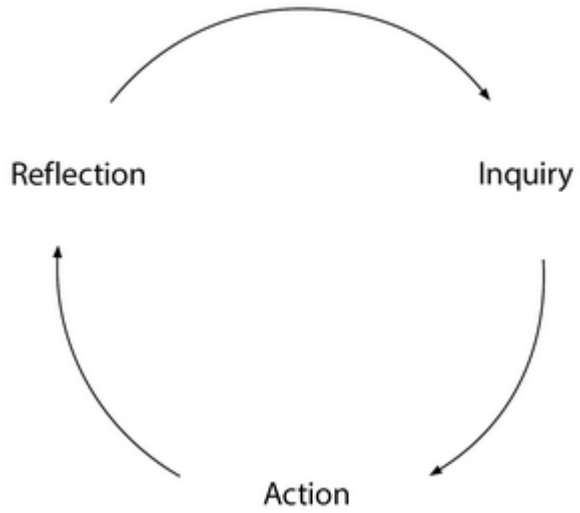
The IB DP recognises that, as an international qualification operating in diverse systems and cultures, there are a variety of strategies and approaches that can be used to support achievement of the IB DP's objectives and intended learning outcomes; and indeed the IB DP explicitly states in its *Programme Standards and Practices* document for schools that teaching and learning [must] use a variety of strategies and incorporate a range of resources and technologies. Student engagement and interaction in particular is highlighted as an essential component of an IB education.

Within the guidelines for schools and teachers, it is clear that both the Swedish and IB systems aim to develop learners capable of thinking and working independently, and of taking responsibility for their own learning. In the IB, this is emphasised throughout all materials from those describing the underpinning philosophy (as discussed in Section 3.1) to those describing standards and practices. IB teachers should employ strategies and approaches that place them not as a provider of knowledge but as a facilitator, helping the students learn how to learn and where "the voice of the learner is considered to be as important as the voice of the teacher" (International Baccalaureate, 2015). Approaches to this are further discussed below.

[16] Under the categories *Knowledge, Norms and values, Responsibility and influence of students, Choice of education – work and societal life, Assessment and grades.*

Less explicitly described in the Swedish teacher guidelines reviewed in the context of this study, is the principle that teaching be based on inquiry: one of the six primary pedagogical principles underpinning all of the IB programmes. Within the classroom, this means that teaching practice should reflect the inquiry learning cycle, as illustrated below:

**Figure 4: The Inquiry learning cycle**




**Source: Diploma Programme: From Principles into Practice (International Baccalaureate, 2015)**

Inquiry-based learning seeks to actively engage learners in the process of learning, where learning is self-directed and the responsibility of the individual student.

The IB defines both approaches to teaching and approaches to learning, with the latter highlighted as:

> *"Encouraging students to view learning as something that they 'do for themselves in a proactive way, rather than as a covert event that happens to them in reaction to teaching' (Zimmerman 2000: 65). By developing ATL skills and the attributes of the learner profile, DP students can become 'self-regulated learners' (Kaplan 1998). Self-regulated learners have learned how to set learning goals, ask good questions, self-interrogate as they learn, generate motivation and perseverance, try out different learning processes, self-monitor the effectiveness of their learning, reflect on achievement, and make changes to their learning processes where necessary (Zimmerman and Schunk 1989; Wolters 2011; de Bruin et al 2011)".* (International Baccalaureate, 2015)

One aspect of the approaches promoted within the Swedish upper secondary system not observed within the IB DP is that teachers should "ensure that teaching in terms of content and its organisation is typified by a gender perspective" (Skolverket, 2013).

### ✔ Apply learning to practical and real-world contexts and support students in developing their ability to see interconnections

Both the Swedish upper secondary school and IB education acknowledge the importance of understanding concepts in context and of ensuring the relevance of this context to the learner, although specific approaches for this are not elaborated upon with the Swedish steering documentation.

### ✔ Make effective use of assessment to enable continuous monitoring of and constructive feedback on the student's knowledge / progress

The guidance for teachers in the Swedish system highlights the importance of monitoring and assessing students' progress, acting upon these findings to regularly provide students with feedback and areas for development, whilst also emphasising the importance of giving students the chance to learn how to self-reflect and self-assess. It is also expected that teachers will work with parents/guardians to further share students' progress.

The IB similarly recognises the importance of formative assessment to student learning. Effective formative assessment enables the teacher to gauge individual student progress, strengths and areas for development and reflect these in their future planning and delivery; while for students, formative assessment and teacher feedback helps the student to better understand their learning and the ways in which they need to develop further. Self-reflection is also important, as shown in the IB Learner Profile attribute "Reflective" where students work to understand their strengths and weaknesses in order to progress their learning and development.

### ✔Appropriately differentiate for varying student needs

From the Education Act through to the *Curriculum for the Upper Secondary School* with its integrated teacher guidelines, the individual needs of the student are emphasised with the expectation that the teacher:

- "Take as the starting point each individual student's needs, circumstances, experiences and thinking,"
- "Reinforce each student's self-confidence, as well as their willingness and ability to learn,"
- "Stimulate, guide and support students and provide special support to students experiencing difficulties,"
- "Organise and carry out work so that students develop in accordance with their own preconditions and at the same time are stimulated to use and develop all their ability,"
- "Receive support in their language and communicative development".

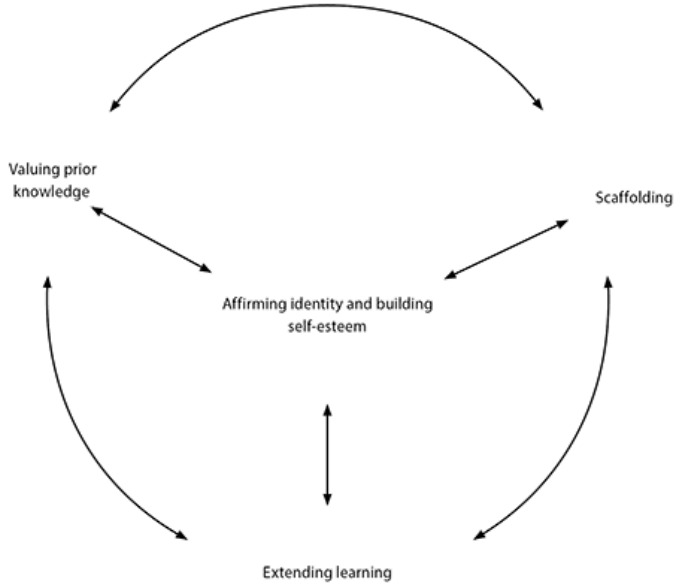
The need to build on what students know and can do; to differentiate based on student learning needs and styles and to address the diversity of student language needs (noting students may not be learning in their mother tongue) is explicitly stated in the IB *Programme Standards and Practices*. This sets out clear standards and requirements that schools provide support (i) for their students' diverse learning needs and (ii) for their teachers to help

ensure that lesson planning and delivery effectively incorporates differentiation strategies for student needs.

As such, considerable guidance is given to IB schools and teachers on the importance of and strategies for differentiation: in short, identifying the best ways to support each learner to achieve the learning goals. In the context of the international provision and diverse cohort of the IB programmes, this also means considering the language profile of each student. This is also relevant in Sweden, noting that there is an acknowledged need to deliver Swedish as a second rather than home language to some students.

Differentiated teaching in the IB should be based on the following principles:

**Figure 5: Principles of good practice for differentiated learning**




**Source: Diploma Programme: From Principles into Practice (International Baccalaureate, 2015)**

This includes but is by no means limited to:

- Fostering realistic but high expectations and in line with this, extending learning wherever possible
- Valuing and making effective use of diversity in cultural perspectives
- Working to identify and respond to individual student interests, learning styles and strengths
- Identifying and highlighting students' prior learning and seeking to build upon this
- Scaffolding learning and facilitating peer support and collaborative activities.

### ✔Employ appropriate strategies to (i) promote democratic values and (ii) develop communication and social skills with a focus on collaborative activities and democratic working

In the Swedish system, these two key principles of teaching are inter-related and strongly emphasised within the guidelines for teachers set out in the *Curriculum for the Upper Secondary School* (Skolverket, 2013), where the expectation is that teachers should organise work so as to promote a sense of: belonging for the student; responsibility towards others less fortunate both in Sweden and beyond; and equality of and respect for all, both individuals and groups.

In particular, it is seen as the role of the teacher to actively promote open discussion within the classroom, be it of different values and of human rights; or of student ideas for the classroom – all students should be able to discuss and have a genuine influence over the content and format of education. To support this, teachers should also work with students to discuss and develop rules for collaborative group work.

The IB's inquiry-based learning or constructivist approach described earlier in this section fosters an open-democratic classroom. The IB education also emphasises the importance of communication, social and collaborative skills and it is one of the stated roles of the IB school and teacher to foster the development of learners, in line with the Learner Profile, that are effective "Inquirers…able to learn with others", "Communicators…able to collaborate effectively, listening carefully to the perspectives of other individuals and groups", "Principled", "Open-minded" and "Balanced"; attributes very much relevant to the Swedish upper secondary goals. To support the development of these attributes, IB teachers are encouraged to employ a mixture of whole class open discussions, collaborative group and individual activities. Collaborative activities may include but would by no means be limited to group projects, role plays, and debates in class and potentially beyond since the IB recommends the use of technology to facilitate communicative and collaborative tasks between students in different parts of the world.

### ✔Possess appropriate subject knowledge and knowledge of pedagogy

In the Swedish system it is highlighted that some of the key "tasks of the upper secondary school are to impart knowledge and to create pre-conditions for students to acquire and develop knowledge" and that teachers should "take account of the results of developments within the subject area, and also relevant pedagogical and other research in their teaching"(Skolverket, 2013).

In 2011, four new professional teaching degrees were introduced, each one focussing on a different level or area of education (pre-school; primary school; subject education; vocational education) with the degree in subject education comprising two specialisations – one for those looking to teach at lower secondary (years 7-9) and one for those looking to teach at upper secondary level. The degrees combine pedagogical studies, subject preparation, a project and a school placement with teachers able, upon completion, to teach two subjects. Those with a non-teaching degree in an appropriate subject may alternatively be able to take a shorter supplementary teacher education programme.

The IB similarly stipulates that the individual school must ensure all those involved in implementing the programme at school level are suitably qualified and receive appropriate professional development.

Also included under this theme is the role of collaboration between the teachers, with the *Curriculum for the Upper Secondary School* in Sweden stating that teachers should "Cooperate with other teachers in order to achieve the goals of education" (Skolverket, 2013). This is detailed somewhat more fully in the IB documentation reviewed, with the *Programme Standards and Practices* (International Baccalaureate, 2014) outlining the role and requirements for collaborative planning whilst the *Diploma Programme: From principles into practice* (International Baccalaureate, 2015) provides further guidance on what collaborative planning should entail.

## 3.3 Research Question 3: Subject Content and Structure

### In what ways does the content and structure of DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL compare with equivalent Swedish upper secondary subjects?

### 3.3.1 Biology

Aims

The *Biology Syllabus* for the Högskoleförberedande examen includes a list of aims that applies to all Biology courses offered (including Biology 1, Biology 2 and Biotechnology). These aims are presented in the table below.

**Table 7: Aims of the Högskoleförberedande examen and IB DP Biology**

| Högskoleförberedande examen – Biology | Included in the IB DP |
|---|---|
| ***Teaching in biology should….*** | |
| Help students develop knowledge of biological concepts, theories, models and working methods | ✓ |
| Contribute to students developing their understanding of the importance of biology in society, such as quality of life and health through medicine, and for the protection of the Earth's ecosystems through ecology | ✓* |
| Give students the opportunity to develop a scientific perspective of the surrounding world based on the theory of evolution | |
| Take advantage of current research and students' experiences, curiosity and creativity | ✓ |
| Help students participate in public debates and discuss ethical issues and views from a scientific perspective | ✓ |
| Cover the development, limitations and areas of applicability of theories and models | ✓* |
| Contribute to students developing the ability to work theoretically and experimentally, and to communicate using scientific language | ✓ |
| Help students develop the ability to critically assess and distinguish between statements based on scientific and non-scientific foundations | ✓* |

| **Högskoleförberedande examen – Biology** | **Included in the IB DP** |
|---|---|
| ***Teaching in biology should….*** | |
| Cover scientific working methods, such as formulating and searching for answers, making systematic observations, planning and carrying out experiments and field studies, as well as processing, interpreting and critically assessing results and information | ✓ |
| Give students the opportunity to discuss and present analyses and conclusions | ✓ |
| Give students the opportunity to use computerised equipment for collecting, simulating, calculating, processing and presenting data. | ✓ |

When comparing the *IB DP Biology Guide,* in particular the aims of the course, in the context of the Swedish Biology courses, it's clear that there are many shared aims. It should be noted that the Swedish Biology aims describe what the teaching should do, but similar to the IB DP, these also indicate what the student should learn to be able to do. In particular, both expect students to develop their knowledge of biology concepts, theories and methods, and experimental and investigative skills. Further, both emphasise that students should develop communication skills and have the opportunity to use current technologies (i.e. "computerised equipment") in a scientific context.

Overall, the IB DP aims are broader and refer to overarching skills and abilities that students should learn and develop; these are then further supported by the IB *Nature of Science* description[17] and the assessment criteria. When comparing these with the Swedish Biology aims, that are more specific, there are some similarities with the IB DP Biology SL course as a whole (i.e. the aims, *Nature of Science*, and assessment criteria). For example, the second Sweden Biology aim above relates to understanding biology in society, life, health, medicine and protecting Earth's ecosystem. The IB DP does not directly aim for students to learn these concepts but rather the *Nature of Science* discusses the importance of science in society, and further, the syllabus makes references to health and medicine and how these relate to the IB DP aim to "become critically aware, as global citizens, of the ethical implications of using science and technology". Therefore this Sweden Biology aim is considered partially included in the IB DP. Also partially included in the IB DP is the aim for students be able to "distinguish between statements based on scientific and non-scientific foundations"; IB DP students conduct critical assessments and evaluate scientific information but identifying the difference between scientific and non-scientific information is not a direct aim.

Other similarities found between the courses include the aims for students to demonstrate their creativity, critically assess and analyse information, and discuss and present their analyses and conclusions. Collaborative learning activities, including debates, are central to the teaching of the IB DP.

One Swedish Biology aim not found in the IB DP course is for students to develop a perspective of science based on the theory of evolution. Although evolution is covered in the

[17] The *Nature of Science* is a section in all of the IB DP science specifications reviewed (i.e. Biology, Chemistry and Physics) that outlines the overarching themes in science across the subjects. All sub-topics in the curriculum are related to the overarching theme of *Nature of Science.*

IB DP curriculum, there are no aims or sections that focus on students developing this overarching perspective focussed on evolution.

## Intended learning outcomes

The *Biology Syllabus* for the Högskoleförberedande examen includes goals that specify what the overall teaching in biology should allow students to develop and which parts of the aims will be graded. Like the aims, these also apply to all of the biology courses. These are presented in the table below:

**Table 8: Learning outcomes and goals of the Högskoleförberedande examen and IB DP Biology**

| **Högskoleförberedande examen – Biology**<br>*Upon completion, students should have:* | **Included in the IB DP** |
|---|---|
| Knowledge of the concepts, models, theories and working methods of biology, and also an understanding of their development | ✓ |
| The ability to analyse and find answers to subject-related questions, and to identify, formulate and solve problems. The ability to reflect on and assess chosen strategies, methods and results | ✓ |
| The ability to plan, carry out, interpret and report field studies, experiments and observations, and also the ability to handle materials and equipment | ✓ |
| Knowledge of the importance of biology for the individual and society | ✓* |
| The ability to use knowledge of biology to communicate, and also to examine and use information. | ✓ |

All of the above Biology goals for the Högskoleförberedande examen are included or partially included in the IB DP across multiple areas of the specification including the aims but also within the IB DP *Nature of Science*. Both the IB DP and the Högskoleförberedande examen require that students have relevant knowledge and skills including the ability to conduct experiments, make observations, and conduct analyses. Communicating their knowledge is also similarly expected.

The Swedish Biology aim for students to have knowledge of the importance of biology for the individual and society is partially included within the IB DP as part of the *Nature of Science* and indirectly through the IB DP aim for student to understand the ethical implications for science; however there is more focus on this idea within the Swedish Biology course.

In addition to the above, the IB DP Biology SL course aims to enable students to develop an appreciation of the limitations of science and technology, its ethical implications, and a critical awareness of the need for collaboration and communication when involved in scientific activities.

## Content

The Högskoleförberedande examen *Biology Syllabus* includes an outline of the content covered in the Biology 2 course. The key topics for this and the IB DP Biology SL course can be seen in the table below:

**Table 9: Content in the Högskoleförberedande examen and IB DP Biology**

| | Högskoleförberedande examen – Biology 2 | IB DP Biology SL |
|---|---|---|
| **Topics** | • Cell and molecular biology<br>• Functions of the organism<br>• The nature of biology and its working methods. | **Core and SL topics**<br>• Cell biology<br>• Molecular biology<br>• Genetics<br>• Ecology<br>• Evolution and biodiversity<br>• Human physiology<br>**Optional topics (teacher pick one)**<br>• Neurobiology and behaviour<br>• Biotechnology and bioinformatics<br>• Ecology and conservation<br>• Human physiology<br>**Practical scheme of work activities**<br>• Practical activities<br>• Individual investigation<br>• Group 4 project. |
| **Number of topics** | 3 | 7 |
| **Recommended teaching hours** | 100 hours | 150 hours |

As shown in the table above, the IB DP Biology SL course addresses many of the same topics as the Högskoleförberedande examen Biology 2 course whilst also covering some additional topics. Similarities in content is demonstrated in the table below which presents the topics and sub-topics from the Högskoleförberedande examen Biology 2 course and whether they are included or partially included within the IB DP Biology SL topics and content.

**Table 10: Content comparison of the Högskoleförberedande examen and IB DP Biology by topic and sub-topic**

| Högskoleförberedande examen - Biology 2 | | Included in the IB DP |
|---|---|---|
| **Cell and molecular biology** | Cell life cycles and differentiation, development from egg to adult. Cell communication | ✓* |
| | Functions of cell division. Life processes and their regulation e.g. photosynthesis, metabolism and transport over membranes. Evolutionary perspectives on molecular biology | ✓ |
| | Application areas of cell and molecular biology. Opportunities, risks and ethical issues | ✓ |
| **Functions of the organism** | Physiology of human beings and other animals. The organ system and its structure, function and interaction. Regulation of the organism through the hormone system and the nervous | ✓ |

| Högskoleförberedande examen - Biology 2 | | Included in the IB DP |
|---|---|---|
| | system | |
| | Relationships between evolution and the functional structure and living processes of organisms | ✓* |
| | The immune system, infection paths and infections. The structure, functions and reproduction of viruses | ✓ |
| | Microorganisms and their importance for health and ill-health. Antibiotics and processes related to evolution | ✓* |
| | Relationships between living conditions, health and ill-health. Ethics of medical issues | |
| | What happens in the body during menstruation, love, sex and pregnancy. How sexually transmittable diseases and unwanted pregnancies can be prevented | ✓* |
| | Life cycles and physiology of plants and funguses | |
| | Use of modern equipment for physiological studies and laboratory experiments | |
| **The nature of biology and its working methods** | Models and theories as representations of reality. Areas where models and theories can be applied, and also how they can be developed, generalised or replaced by other models and theories over time | ✓* |
| | Identifying and studying problems and issues using reasoning from biology | ✓ |
| | The importance of experimental work in testing, re-assessing and revising hypotheses, theories and models | ✓* |
| | Planning and carrying out field studies, experiments and observations, and the formulation and testing of hypotheses related to this. Assessing results and conclusions by analysing choice of methods, work processes and sources of error | ✓ |
| | Physiological studies and experiments also covering the use of modern equipment. Simple methods of molecular biology. Sterilisation and cultivation of bacteria | |
| | Use of genetic data for the study of biological contexts | ✓* |
| | Issues concerning religion, ethics and sustainable development linked to different working approaches of biology and its areas. | |

As indicated in the table above, some Swedish sub-topics are not included in the IB DP Biology SL course. For example, relationships between living conditions, health and ill-health and ethics surrounding medical issues are not topics found within the IB DP. However, as is also indicated in the table, the comparative analysis has found that many of the Swedish Biology 2 topics are included or partially included in the IB DP Biology SL course. For example, cell and molecular biology are key topics in both courses with each similarly including sub-topics and content on cell division, photosynthesis, membrane transport, and

ethical issues in a biology context. Human physiology, infectious diseases and the immune system are also similarly included. The experimental and practical skills, such as using reasoning and testing hypothesis, from the third Swedish topic area on the nature of biology and its working methods are also similarly taught and assessed within the IB DP.

The Swedish content regarding the "development from egg to adult", "microorganisms and their importance for health and ill-health", and "how sexually transmittable diseases and unwanted pregnancies can be prevented" however are not found within the IB DP Biology SL course. As this content is part of a larger section or topic in the Swedish course where the remaining content was found within the IB DP Biology SL course, these have been marked as partially included.

### 3.3.2 Chemistry

Aims

The aims of the *Chemistry Syllabus* for the Högskoleförberedande examen apply to both of the courses offered including Chemistry 1 and Chemistry 2. The aims are nearly identical to those in the Biology and Physics syllabi (discussed in sections 3.3.1 and 3.3.3 respectively) with the exception of the first four aims in the table below.

**Table 11: Aims of the Högskoleförberedande examen and IB DP Chemistry**

| **Högskoleförberedande examen – Chemistry**<br>***Teaching in chemistry should….*** | **Included in the IB DP** |
|---|---|
| Aim at helping students develop knowledge of the concepts, theories, models and methods of chemistry | ✓ |
| Contribute to students developing knowledge of both natural and man-made chemical processes | ✓ |
| Help students develop their understanding of the importance of chemistry for climate, the environment and the human body, knowledge of different applications of chemistry in areas such as the development of new medicines, new materials and new technologies | ✓ |
| Give students the opportunity to develop a scientific approach to the surrounding world | ✓* |
| Take advantage of current research and students' experiences, curiosity and creativity | ✓ |
| Help students participate in public debates and discuss ethical issues and views from a scientific perspective | ✓ |
| Cover the development, limitations and areas of applicability of theories and models | ✓* |
| Contribute to students developing the ability to work theoretically and experimentally, and to communicate using scientific language | ✓ |
| Help students develop the ability to critically assess and distinguish between statements based on scientific and non-scientific foundations | ✓* |
| Cover scientific working methods such as formulating and searching for answers to questions, planning and carrying out experiments and processing, interpreting and | ✓ |

| Högskoleförberedande examen – Chemistry<br>***Teaching in chemistry should….*** | Included in the IB DP |
|---|---|
| critically assessing results and information | |
| Give students the opportunity to discuss and present analyses and conclusions | ✓ |
| Give students the opportunity to use computerised equipment for collecting, simulating, calculating, processing and presenting data. | ✓ |

Similar to the Högskoleförberedande examen, the IB DP also applies the same aims (including the *Nature of Science* and the assessment criteria) across the science subjects and therefore, broadly the same conclusions can be drawn on how these two courses relate.

Both courses aim for students to develop the relevant chemistry knowledge, including, as specified in the second Swedish Chemistry aim, knowledge of natural and man-made chemical processes. Although this specific concept is not referenced in the IB DP aims, natural phenomena and synthetic materials are frequently referenced in the IB DP curriculum.

The third aim for the Swedish Chemistry course is also similarly included within the IB DP. Although not directly referenced in the IB DP aims, the *Nature of Science* and curriculum highlight climate change and how this relates to the IB DP aim for students to be able to "become critically aware, as global citizens, of the ethical implications of using science and technology". Further, both courses refer to how chemistry relates to the environment and the human body within the curriculum and the IB DP aim regarding the possibilities of science and technology is similar to the aim for the Swedish students to understand the application of chemistry to develop new medicine, materials and technologies.

Lastly, the fourth aim in the table above, although similar to the Sweden Biology aim from the previous section, has been altered to fit the chemistry context (i.e. it no longer refers to evolution). The IB DP does not have any directly similar aims or concepts, but it does aim for students to understand how science applies to other fields or the wider implications of science; further the curriculum includes descriptions on how topics or content can apply to real-world applications.

## Intended learning outcomes

The *Chemistry Syllabus* for the Högskoleförberedande examen includes goals that specify which parts of the aims above will be graded and what the overall teaching in chemistry should allow students to develop. Like the aims, these also apply to all of the chemistry courses. These are presented in the table below:

**Table 12: Learning outcomes and goals of the Högskoleförberedande examen and IB DP Chemistry**

| Högskoleförberedande examen – Chemistry | Included in the IB DP |
|---|---|
| Knowledge of chemical concepts, models, theories and working methods, and understanding their development | ✓ |
| The ability to analyse and find answers to subject-related questions, and to identify, formulate and solve problems. The ability to reflect on and assess chosen strategies, methods and results | ✓ |
| The ability to plan, carry out, interpret and report experiments and observations, and also the ability to handle chemicals and equipment | ✓ |
| Knowledge of the importance of chemistry for the individual and society | ✓* |
| The ability to use a knowledge of chemistry to communicate, and also to examine and use information. | ✓ |

As with the aims, the Sweden Chemistry goals are broadly the same as those used for the Sweden Biology course. The IB DP similarly defines intended learning outcomes and *Nature of Science* to apply across the sciences, and therefore the table above reflects the conclusions discussed in section 3.3.1.

Content

The Högskoleförberedande examen *Chemistry Syllabus* includes an outline of the content covered in the Chemistry 2 course. The key topics for this and the IB DP Chemistry SL can be seen in the table below:

**Table 13: Content in the Högskoleförberedande examen and IB DP Chemistry**

| | Högskoleförberedande examen – Chemistry 2 | IB DP Chemistry SL |
|---|---|---|
| **Topics** | • Reaction speed and chemical equilibrium<br>• Organic chemistry<br>• Biochemistry<br>• Analytical chemistry<br>• The nature of chemistry and its working methods. | **Core and SL Topics**<br>• Stoichiometric relationships<br>• Atomic structure<br>• Periodicity<br>• Chemical bonding and structure<br>• Energetics/thermochemistry<br>• Chemical kinetics<br>• Equilibrium<br>• Acids and bases<br>• Redox processes<br>• Organic chemistry<br>• Measurement and data processing<br>**Optional topics (teachers pick one)**<br>• Materials<br>• Biochemistry<br>• Energy |

| | Högskoleförberedande examen – Chemistry 2 | IB DP Chemistry SL |
|---|---|---|
| | | • Medicinal chemistry<br>**Practical scheme of work activities**<br>• Practical activities<br>• Individual investigation<br>• Group 4 project. |
| **Number of topics** | 5 total | 12 total |
| **Recommended Teaching hours** | 100 hours | 150 hours overall |

Both the Högskoleförberedande examen and IB DP cover a set of key topics in chemistry as seen in the table above. Although the IB DP covers more topics than the Högskoleförberedande examen, when considering how the content itself compares the table below illustrates how the IB DP covers much of the content found within the Chemistry 2 course.

**Table 14: Content comparison of the Högskoleförberedande examen and IB DP Chemistry by topic and sub-topic**

| Högskoleförberedande examen - Chemistry 2 | | Included in the IB DP |
|---|---|---|
| **Reaction speed and chemical equilibrium** | Reaction speed, e.g. the effect of catalysts and concentrations on how quickly chemical reactions take place | ✓ |
| | Factors affecting equilibrium and equilibrium constants | ✓ |
| | Calculations of and reasoning about equilibrium systems in different environments e.g. in oceans, in the human body and in industrial processes | ✓ |
| **Organic chemistry** | Different categories of organic substances, their properties, structure and reactivity | ✓ |
| | Reaction mechanisms, including qualitative reasoning about how and why reactions take place, and about the rate of use of energy in different kinds of organic reactions | ✓* |
| **Biochemistry** | The genetic flow of information, including the main elements of the replication of biochemical processes, transcription and translation | ✓* |
| | The main features of human metabolism at the molecular level | ✓ |
| | Structure and function of proteins, with special focus on enzymes | ✓ |
| **Analytical chemistry** | Qualitative and quantitative methods of chemical analysis e.g. mass spectrometry and spectrophotometry | ✓ |
| | Reasoning concerning sampling, level of detection, correctness and accuracy, and also systematic and random sources of error | ✓ |

| Högskoleförberedande examen - Chemistry 2 | | Included in the IB DP |
|---|---|---|
| **The nature of chemistry and its working methods** | Models and theories as simplifications of reality. Models and their areas of applicability and how they can be developed, generalised or replaced by other models and theories over time | ✓ |
| | Identifying and studying problems and issues using reasoning from chemistry | ✓ |
| | The importance of experimental work in testing, re-assessing and revising hypotheses, theories and models | ✓ |
| | Planning and implementation of experimental investigations and observations, and formulating and testing hypotheses in connection with this | ✓ |
| | Assessing results and conclusions by analysing choice of methods, work processes and sources of error | ✓ |
| | Issues concerning ethics and sustainable development linked to different ways of working in chemistry and activity areas. | ✓ |

All of the Swedish Chemistry 2 topics are included or partially included within the IB DP Chemistry SL course. In particular, many of the above Swedish topics are similarly included within the IB DP core topics on *Chemical kinetics, Equilibrium, Organic Chemistry,* and *Measurement and data processing.* For example the first three content areas under the Swedish topic on *Reaction speed and chemical equilibrium* are similar to areas taught within the IB DP topics on *Chemical Kinetics* and *Equilibrium.* Further, the Swedish topic on *Analytical Chemistry* covers mass spectrometry, accuracy, systematic and random errors which are also taught within the IB DP section on *Measurement and data processing.* The IB DP optional topic on *Biochemistry* also includes many of the same broad topics on biochemistry as seen in the table above.

Two of the above content areas in Swedish Chemistry 2 are only partially included in the IB DP as some of the Swedish content is not included. The key terms *transcription and translation* are taught under the Swedish topic on *Biochemistry* but in the IB DP specification it is specified that students are not required to know these. For the content related to organic reactions under the Swedish topic on *Organic Chemistry* these partially aligned with content in the IB DP Chemistry HL rather than the SL course.

The practical section of the Swedish Chemistry 2, titled *The nature of chemistry and its working methods*, is a key feature of the Swedish content outline. These are also taught within and included throughout the IB DP curriculum. Although there isn't a set topic within the IB DP, the experimental and analytical skills are specified separately and linked to the practical work and individual investigation completed by the student. For example, students are assessed on their evaluation skills in the individual investigation, including their ability to assess and improve on the strengths and weaknesses of their investigation and methodological issues.

The IB DP Chemistry SL course is of a larger breadth with many further key topics discussed within the course such as *Atomic Structure* and *Periodicity.*

### 3.3.3 Physics

Aims

The aims of the *Physics Syllabus* for the Högskoleförberedande examen apply to all of the Physics courses. The aims are nearly identical to those in the Biology and Chemistry Syllabi with the exception of the second and last aim in the table below:

**Table 15: Aims of the Högskoleförberedande examen and IB DP Physics**

| Högskoleförberedande examen - Physics<br>***Teaching in physics should….*** | Included in the IB DP |
|---|---|
| Aim at helping students develop knowledge of the concepts, theories, models and working methods of physics | ✓ |
| Contribute to students developing knowledge about different applications of physics in areas such as technology, medicine and sustainable development, thereby enhancing understanding of the importance of physics in society | ✓* |
| Give students the opportunity to develop a scientific approach to the surrounding world | ✓* |
| Take advantage of current research and students' experiences, curiosity and creativity | ✓ |
| Help students participate in public debates and discuss ethical issues and views from a scientific perspective | ✓ |
| Cover the development, limitations and areas of applicability of theories and models | ✓* |
| Contribute to students developing the ability to work theoretically and experimentally, and to communicate using scientific language | ✓ |
| Help students develop the ability to critically assess and distinguish between statements based on scientific and non-scientific foundations | ✓* |
| Cover scientific working methods such as formulating and searching for answers, planning and carrying out observations and experiments, and processing, interpreting and critically assessing results and information | ✓ |
| Given the opportunity to analyse and solve problems through reasoning based on concepts and models, both with and without the use of mathematics. | ✓ |

As demonstrated in the table above all of the aims of the Högskoleförberedande examen for Physics are included or partially included in IB DP Physics SL. The majority of these Swedish aims are the same as those used in the Biology and Chemistry courses compared in the previous sections and in those cases the same findings apply. The IB DP aims, *Nature of Science,* and curriculum demonstrate similar aims to those presented above.

The Swedish and IB DP Physics courses both aim for students to develop key knowledge and practical skills including the ability to plan and conduct experiments and assess results. Applying the student's curiosity and creativity to their learning is also a focus.

The last aim in the table above is new to the Högskoleförberedande examen for Physics and not found within the other science subjects. This aim is similarly included within the IB DP course as both aim for students to analyse information and to apply mathematics to physics problems, or in some cases to solve problems without mathematics.

## Intended learning outcomes

The *Physics Syllabus* for the Högskoleförberedande examen includes goals that specify what the overall teaching in physics should allow students to develop and which parts of the aims will be graded. Like the aims, these also apply to all of the physics courses. These are presented in the table below:

**Table 16: Learning outcomes of the Högskoleförberedande examen and IB DP Physics**

| Högskoleförberedande examen – Physics | Included in the IB DP |
|---|---|
| Knowledge of the concepts, models, theories and working methods of physics, and also understanding their development | ✓ |
| The ability to analyse and find answers to subject-related questions, and to identify, formulate and solve problems. The ability to reflect on and assess chosen strategies, methods and results | ✓ |
| The ability to plan, carry out, interpret and report experiments and observations, and also the ability to handle materials and equipment | ✓ |
| Knowledge of the importance of physics for the individual and society | ✓* |
| The ability to use a knowledge of physics to communicate, and also to examine and use information. | ✓ |

As previously noted, the IB DP has shared aims, assessment criteria and *Nature of Science* across its science courses; and this is similarly true for the Högskoleförberedande examen where the aims are largely shared across Physics, Chemistry and Biology. The table above illustrates that in both Physics courses, there are integral aims for students to develop key knowledge and skills in physics, including the ability to carry out practical work and communicate their knowledge and findings.

## Content

The Högskoleförberedande examen *Physics Syllabus* includes an outline of the content covered in the Physics 2 course. The key topics for this and the IB DP Physics SL course can be seen in the table below:

**Table 17: Content in the Högskoleförberedande examen and IB DP Physics**

| | Högskoleförberedande examen - Physics 2 | IB DP Physics SL |
|---|---|---|
| **Topics** | • Motion and force<br>• Waves, electromagnetism and signals<br>• The development and structure of the universe<br>• The nature, working methods, and mathematical methods of physics | **Core topics**<br>• Measurements and uncertainties<br>• Mechanics<br>• Thermal physics<br>• Waves<br>• Electricity and magnetism<br>• Circular motion and gravitation<br>• Atomic, nuclear and particle physics<br>• Energy production<br>**Optional topics (teachers select one)**<br>• Relativity<br>• Engineering physics<br>• Imaging<br>• Astrophysics<br>**Practical scheme of work activities**<br>• Practical activities<br>• Individual investigation (internal assessment – IA)<br>• Group 4 project. |
| **Number of topics** | 4 total | 9 total |
| **Recommended Teaching hours** | 100 hours | 150 hours |

The table above demonstrates the topics covered in both the IB DP and Högskoleförberedande examen. When considering how the content compares, the table below demonstrates how many of the Högskoleförberedande examen topics are found within the IB DP.

**Table 18: Content comparison of the Högskoleförberedande examen and IB DP Physics by topic and sub-topic**

| Högskoleförberedande examen - Physics 2 | | Included in the IB DP |
|---|---|---|
| **Motion and force** | Two-dimensional motion in gravitational fields and electrical fields | ✓ |
| | Central motion | ✓*[18] |
| | Torque to describe states of equilibrium | ✓ |

[18] In this instance the information publically available on the Physics 2 course does not provide sufficient detail on what this topic entails to determine whether the IB DP provides full coverage and accordingly only partial coverage can be confirmed, noting that concepts of motion and force are included in the IB DP.

| Högskoleförberedande examen - Physics 2 | | Included in the IB DP |
|---|---|---|
| | Simulating two-dimensional motion using simple numerical methods | |
| **Waves, electromagnetism and signals** | Harmonic oscillation as a model for describing phenomena in everyday life and technology | ✓ |
| | Reflection, refraction and interference of light, sound and other wave motion | ✓ |
| | Harmonic oscillation and resonance with applications in everyday life and technology | ✓* |
| | Orientation to volume and Doppler effects | |
| | Relationships between electrical and magnetic fields: magnetic fields around current carrying conductors, motion of electric charges in magnetic fields, induction and some applications e.g. alternating current generators and transformers | ✓ |
| | Wave and particle descriptions of electromagnetic radiation. Orientation to propagation of electromagnetic waves. Photoelectric effects and the concept of photons | ✓* |
| | Wave properties of matter: de Broglie's hypotheses and wave-particle duality | |
| | Physics principles underlying technical applications for communication and detection | ✓* |
| **The development and structure of the universe** | Orientation to current models and theories for describing the universe's large-scale development and formation of galaxies, stars and planets | ✓* |
| | The electron structure of atoms, and absorption and emission spectra | ✓ |
| | Methods for studying the universe. Electromagnetic radiation from stars and interstellar space | ✓* |
| | Methods for identifying and studying exoplanets. Conditions for life on other planets | |
| **The nature, working methods, and mathematical methods of physics** | Models and theories as simplifications of reality. Models and their areas of applicability and how they can be developed, generalised or replaced by other models and theories over time | ✓ |
| | The importance of experimental work in testing, re-assessing and revising hypotheses, theories and models | ✓ |
| | Identifying and studying problems using reasoning from physics and mathematical modelling covering linear and non-linear functions, equations and graphs, and derivatives and vectors | ✓ |
| | Planning and implementation of experimental investigations and observations, and formulating and testing hypotheses in | ✓ |

| Högskoleförberedande examen - Physics 2 | | Included in the IB DP |
|---|---|---|
| | connection with this | |
| | Processing and assessing data and results using regression analysis, analysis of graphs, unit analysis, and estimates of size | ✓* |
| | Assessing results and conclusions by analysing choice of methods, work processes, sources of error and measuring uncertainty | ✓ |
| | Relations and links between physics and ethical, philosophical and religious issues. | ✓* |

As the table above shows, the majority of the Swedish Physics 2 content is included or partially included in the IB DP. Motion and force are key topics in the Swedish Physics 2 course and are included as sub-topics under *Mechanics* in the IB DP. The topic of *Waves* is also included in both courses, with similar content taught related to oscillations, reflection and refraction.

For some of those topics marked as 'partially included', it should be noted that they form part of the content taught at IB DP HL rather than SL. For example, although the Swedish content on *Waves, electromagnetism and signals* related to harmonic oscillations is found in the IB DP specification for Physics SL, the key concept of resonance is only taught in Physics HL. Other content found in the Physics HL course rather than the Physics SL course includes the Swedish topics related to the photoelectric effect and photons.

Some of the Swedish content was only partially found, or identified as being indirectly included (i.e. similar to parallel physics topics rather than a direct focus) in the IB DP Physics course (not in SL or HL) and may reflect a different focus for the courses. Further, under working methods, the focus on using a regression and unit analyses or examining philosophical issues is not found in the IB DP.

The remaining topics identified as not included in the IB DP Physics SL are often partially or fully included in the IB DP Physics HL topics; this includes the topics related to Doppler effect, de Broglie's hypotheses and wave-particle duality. The Swedish topic on exoplanets and life on other planets and "simulating two-dimensional motion using simple numerical methods" were not identified within the IB DP specification.

### 3.3.4 Mathematics

The comparative analysis of the mathematics courses in the Högskoleförberedande examen and IB DP consist of a selection of the courses offered in each qualification; in particular, Mathematics 3c, Mathematics 4 and 5 in the Högskoleförberedande examen and Mathematics SL and HL and Mathematical Studies SL in the IB DP. Further information on the mathematics courses offered in each qualification is provided below

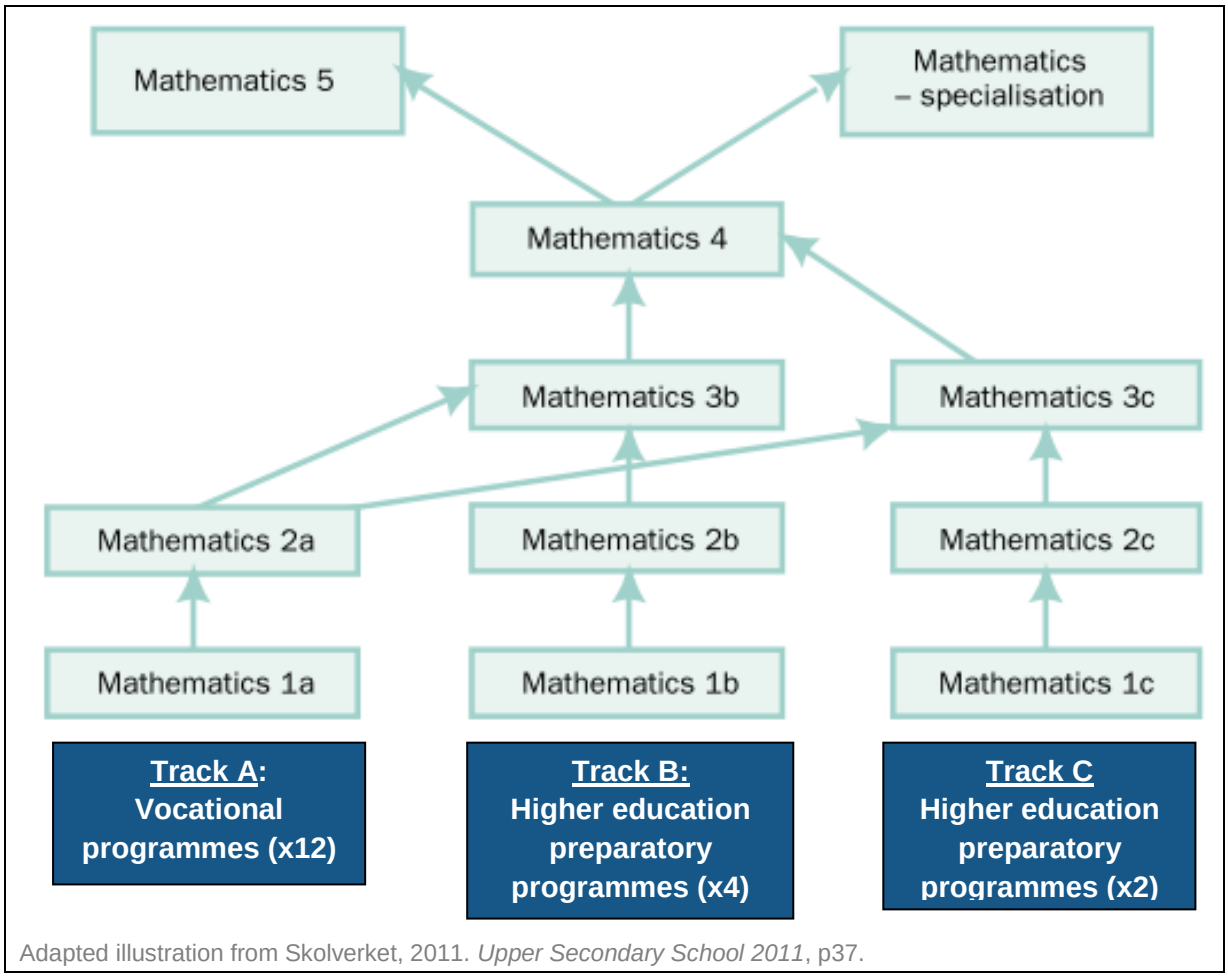
## Programme structure

There are four IB DP mathematics courses:

- Mathematical Studies SL
- Mathematics SL
- Mathematics HL
- Further Mathematics HL.

This study considers how the first three courses listed compare in the context of the Swedish education system, namely in the Högskoleförberedande examen. There are a number of mathematics courses within the Swedish upper secondary system, with different tracks depending on the student's chosen national programme. This can be illustrated as follows:

**Figure 6: Track structure of the Högskoleförberedande examen**




Adapted illustration from Skolverket, 2011. *Upper Secondary School 2011*, p37.

With reference to Figure 6, students who have completed vocational programmes in Track A (the introductory course 1a and supplementary course 2a) can transfer to track B or C for their third course. Mathematics courses 4, 5 and the specialisation course can be taken on completion of tracks B and C, or by students who transferred to Mathematics 3b or 3c on completion of track A's supplementary course (course 2a).

For each of the higher education preparatory programmes in tracks B and C, the compulsory and elective Högskoleförberedande examen courses (as documented in *Upper Secondary School 2011*, a report by Skolverket) are shown in Table 19.

**Table 19: Compulsory and elective Högskoleförberedande examen mathematics courses by Track B / C Programme**

| | Higher Education preparatory programme | | | | | |
|---|---|---|---|---|---|---|
| | Track B | | | | Track C | |
| **Mathematics course** | Business Management and Economics | Arts | Humanities | Natural Science | Social Science | Technology |
| 1b | C | C | C | - | C | - |
| 2b | C | - | - | - | C | - |
| 3b | E | - | - | - | - | - |
| 1c | - | - | - | C | - | C |
| 2c | - | - | - | C | - | C |
| 3c | - | - | - | C | - | C |
| 4 | - | - | - | E | - | E |

C = Compulsory course
E = Elective course

## Aims

The *Mathematics Syllabus* for the Högskoleförberedande examen (i.e. for Mathematics 3c, 4, and 5) includes a list of aims describing what teaching in the subject should aim to do, which are presented in the table below. These apply to all the mathematics courses and provide a further indication of the knowledge, understanding and skills the Högskoleförberedande examen courses intend to develop.

**Table 20: Aims of the Högskoleförberedande examen and IB DP Mathematics courses**

| **Högskoleförberedande examen – Mathematics** | **Included in the IB DP** |
|---|---|
| ***Teaching in mathematics should….*** | |
| Aim at students developing their ability to work mathematically. This involves developing an understanding of mathematical concepts and methods, as well as different strategies for solving mathematical problems and using mathematics in social and professional situations | ✓ |
| Give students the opportunity to challenge, deepen and broaden their creativity and mathematical skills | ✓ |
| Contribute to students developing the ability to apply mathematics in different contexts, and understand its importance for the individual and society | ✓ |
| Cover a variety of working forms and methods of working, where investigative activities form a part | ✓ |
| Give students the opportunity to communicate using different forms of expression | ✓ |

| Högskoleförberedande examen – Mathematics<br>***Teaching in mathematics should….*** | Included in the IB DP |
|---|---|
| Provide students with challenges, as well as experience in the logic, generalisability, creative qualities and multifaceted nature of mathematics | ✓ |
| Strengthen students' confidence in their ability to use mathematics in different contexts, and provide scope for problem solving both as a goal and an instrument | ✓ |
| Give students the opportunity to develop their ability to use digital technology, digital media, and other tools which can occur in subjects typical of programmes. | ✓ |

Analysis of the IB DP Mathematics course guides reveal they aim to develop similar knowledge, understanding and skills expected in the Högskoleförberedande examen. Overall this includes thinking mathematically (including critically and creatively), communicating mathematically, and applying mathematical solutions (e.g. solving problems with confidence using concepts and methods in different contexts).

The multifaceted nature and universality of mathematics is recognised in the introduction and aims of the IB DP Mathematics courses, particularly in relation to appreciating past, present and future contributions of mathematics to the discipline and more widely (including the influence of mathematics on technology and vice versa), and moral, social, and ethical implications of mathematics and perspectives in mathematics.

## Intended learning outcomes

Within the subject aims of the Högskoleförberedande examen syllabus, there are seven learning outcomes applying to all Högskoleförberedande examen mathematics courses that describe the knowledge, understanding and skills students should develop from taking each course. These are shown in the table below.

**Table 21: Learning outcomes of the Högskoleförberedande examen and IB DP Mathematics HL and SL**

| Högskoleförberedande examen – Mathematics | Included in the IB DP HL and SL | Included in Mathematical Studies SL |
|---|---|---|
| Use and describe the meaning of mathematical concepts and their inter-relationships | ✓ | ✓ |
| Manage procedures and solve tasks of a standard nature with and without tools | ✓ | ✓ |
| Formulate, analyse and solve mathematical problems, and assess selected strategies, methods and results | ✓ | ✓ |
| Interpret a realistic situation and design a mathematical model, as well as use and assess a model's properties and limitations | ✓ | ✓* |
| Follow, apply and assess mathematical reasoning | ✓ | ✓ |
| Communicate mathematical thinking orally, in writing, and in action | ✓ | ✓ |
| Relate mathematics to its importance and use in other | ✓ | ✓ |

| Högskoleförberedande examen – Mathematics | Included in the IB DP HL and SL | Included in Mathematical Studies SL |
|---|---|---|
| subjects, in a professional, social and historical context. | | |

*IB DP Mathematics HL and SL:*

Analysis of the IB DP Mathematics HL and SL course guides reveals learning outcomes similar to the Högskoleförberedande examen, with emphasis on developing knowledge (including concepts and models) and understanding in mathematics (e.g. contexts) and developing skills in formulating and solving problems (by-hand or using technology), analysis and evaluation (through inquiry), design and mathematical reasoning.

Written communication is a further skill assessed in the IB DP Mathematics HL and SL courses. Development of mathematical thinking orally is not an explicit learning outcome in the IB Mathematics HL and SL syllabuses; however, it is acknowledged that students do engage in mathematical discussions with teachers in the classroom and for their internally-assessed exploration, students can discuss their choice of topic with teachers as well as carry out data collection and/or measurement-generation activities.

*IB DP Mathematical Studies SL:*

As with the IB DP Mathematics HL and SL courses, the IB DP Mathematical Studies SL course emphasises developing knowledge (including concepts and models) and understanding in mathematics (e.g. contexts). In terms of skills, whilst the IB DP Mathematical Studies SL syllabus has evidence of formulating and solving problems (by-hand or using technology), analysis and evaluation (through inquiry), and mathematical reasoning, designing a mathematical model was not explicitly evident although more generally students would be expected to interpret a realistic situation.

As with the Mathematics HL and SL courses, the extent to which the IB DP Mathematical Studies SL course assesses oral communication of mathematical thinking is not explicitly defined. Written communication of mathematical thinking is an integral part of the IB DP Mathematical Studies SL course and students are evaluated through an internally-assessed project, whilst the specification makes clear the expectation that students discuss their project (verbally) during class time but they are not formally assessed on their verbal communication.

Content

For the Högskoleförberedande examen mathematics courses 3c, 4 and 5 and IB DP Mathematics SL and HL courses, Table 22 contains a broad outline of the subject areas covered.

**Table 22: Content in the Högskoleförberedande examen Mathematics (3c, 4, 5) and IB DP Mathematics SL and HL**

| | Högskoleförberedande examen | IB DP Mathematics |
|---|---|---|
| **Topics** | Mathematics 3c and 4:<br>• Arithmetic, algebra and geometry<br>• Relationships and change<br>• Problem solving<br>Mathematics 5:<br>• Relationships and change<br>• Discrete mathematics<br>• Problem solving | Mathematical Studies SL (core subjects studied):<br>• Number and Algebra<br>• Descriptive Statistics<br>• Statistical applications<br>• Geometry and trigonometry<br>• Logic, sets and probability<br>• Mathematical models<br>• Introduction to differential calculus<br>• *Project (individual internal assessment)*<br><br>Mathematics SL (core studies):<br>• Algebra<br>• Functions and Equations<br>• Circular Functions and Trigonometry<br>• Vectors<br>• Statistics and probability<br>• Calculus<br>• *Mathematical exploration (individual internal assessment)*<br><br>Mathematics HL (core studies):<br>• Algebra<br>• Functions and Equations<br>• Circular Functions and Trigonometry<br>• Vectors<br>• Statistics and probability<br>• Calculus<br>• *Mathematical exploration (individual internal assessment)*<br>(elective studies):<br>• Statistics and Probability<br>• Sets, Relations and Groups<br>• Calculus<br>• Discrete Mathematics |
| **Number of topics** | Mathematics 3c and 4: Three topics<br>Mathematics 5: Three topics | Mathematical Studies SL: Seven core topics and a *project (individual internal assessment)*<br><br>Mathematics SL: Six core topics and a *Mathematical exploration (individual internal assessment)* |

| | Högskoleförberedande examen | IB DP Mathematics |
|---|---|---|
| | | Mathematics HL: Six core topics and a *Mathematical exploration (individual internal assessment);* one elective topic |
| **Recommended teaching hours** | 100 hours in each | Mathematical Studies SL: 150 hours<br>Mathematics SL: 150 hours<br>Mathematics HL: 240 hours |

The table above demonstrates the key topic areas covered in the Högskoleförberedande examen and IB DP mathematics courses examined in this study. To understand how the content compares, the following tables demonstrate how many of the Högskoleförberedande examen mathematics topics within each course can be identified within the IB DP courses.

## IB DP Mathematics and Högskoleförberedande examen Mathematics 3c course content comparison

The following comparison focusses on all three IB DP Mathematics courses (Mathematics HL, SL and Mathematical Studies SL).

In some cases, the Swedish topics are similar to topics included in the IB DP list of expected prior learning (before completing the IB DP). For example, “the concept of absolute values” is part of the expected knowledge on numbers to know the “definition and elementary treatment of absolute value (modulus), |*a*|”. These have been highlighted in the tables below as ‘Expected Prior Learning’.

**Table 23: Content comparison of the IB DP Mathematics and Högskoleförberedande examen Mathematics 3c course**

| Högskoleförberedande examen - Mathematics 3c | | Included in the IB DP Mathematics HL | Included in the IB DP Mathematics SL | Included in the IB DP Mathematical Studies SL |
|---|---|---|---|---|
| **Arithmetic, algebra and geometry** | The concept of absolute values | Expected Prior Learning | Expected Prior Learning | |
| | The concepts of polynomial and rational expressions, and generalisation of the laws of arithmetic, for dealing with these concepts | ✓ | ✓* | |
| | Properties of the equation of a circle and unit circle in defining trigonometric concepts | ✓* | ✓* | |
| | Proof and use of cosine, sine and area theorems for an arbitrary triangle | ✓ | ✓ | ✓ |
| **Relationships and change** | Orientation to continuous and discrete functions, as well as the concept of limits | ✓ | ✓ | ✓* |

| Högskoleförberedande examen - Mathematics 3c | | Included in the IB DP Mathematics HL | Included in the IB DP Mathematics SL | Included in the IB DP Mathematical Studies SL |
|---|---|---|---|---|
| | Properties of polynomial functions of higher orders | ✓ | | |
| | The concepts of secant, tangent, rate of change and derivatives of a function | ✓ | ✓* | ✓* |
| | Derivation and use of the rules of derivation for power and exponential functions, and also sums of functions | ✓ | ✓ | |
| | Introduction of the number "e" and its properties | ✓ | ✓ | |
| | Algebraic and graphical methods for determining the value of the derivative of a function | ✓ | ✓ | ✓ |
| | Algebraic and graphical methods for solving extreme value problems using sign tables and second derivatives | ✓ | ✓ | |
| | Relationship between the graph of a function and the first and second derivatives of a function | ✓ | ✓ | ✓* |
| | The concept of antiderivatives and definite integrals and the relationship between integrals and derivatives | ✓ | ✓ | |
| | Determining simple integrals in applications relevant for subjects typical of programmes | ✓ | ✓ | |
| **Problem solving** | Strategies for mathematical problem solving including the use of digital media and tools | ✓ | ✓ | ✓ |
| | Mathematical problems of importance in societal life and applications in other subjects | ✓ | ✓ | ✓ |
| | Mathematical problems related to the cultural history of mathematics. | ✓ | ✓ | ✓ |

Overall, Mathematics 3c is well covered by the IB DP Mathematics HL and SL, and partially by the IB DP Mathematical Studies SL course. The Swedish Problem Solving topics are fully included in all three IB DP programmes. IB DP Mathematics HL has all of the Swedish topics and sub-topics included or partially included, and the IB DP Mathematics SL has nearly all included to some extent.

*Comparative analysis of IB Mathematics HL course to Högskoleförberedande examen Mathematics 3c*

As shown in the table above the majority of the content in the Högskoleförberedande examen Mathematics 3c course is fully included in the IB DP Mathematics HL course; one topic is partially included. For example, both courses similarly cover the following content related to problem-solving:

- Using both formula and technology in algebra (Topic 1 – Core: Algebra)
- Applying algebra to compound interest and population growth (Topic 1 – Core: Algebra) and solving problems in compound interest and debt repayment (Optional topic – Discrete Mathematics)
- Kinematics problems - in particular whether kinematics being a core maths reflects a particular cultural heritage (Topic 6 – Core: Calculus).

Content related to the Swedish topic on relationships and change is also found within the IB DP. For example, the IB DP similarly covers derivatives of a function (first and second), polynomial functions, number “e”, antiderivatives, definite integrals and simple integrals.

Both courses similarly include content related to arithmetic, algebra and geometry; in particular the IB Mathematics HL course covers content related to trigonometric functions using unit circles, and the use of cosine, sine and area theorems for an arbitrary triangle. These are covered in IB DP core topic on circular functions and trigonometry. However, properties of the equation of a circle are not included in the IB DP and although the remaining Swedish content on unit circles is included, this overall topic is partially included in the IB DP.

The definition and elementary treatment of absolute values is referenced in the IB Mathematics HL course as Expected Prior Learning, therefore on entry to the IB Mathematics HL course students would be expected to be familiar with this, otherwise teachers must cover this topic at an early stage of the course. The IB Mathematics HL course also includes polynomials and arithmetic in various core and optional topics and rational functions in Topic 2 (Core: Functions and Equations).

*Comparative analysis of IB Mathematics SL course to Högskoleförberedande examen Mathematics 3c*

The content of the IB DP Mathematics SL course compares to the Högskoleförberedande examen Mathematics 3c course in much of the same areas as the IB DP Mathematics HL course. For example, knowledge of the concept of absolute values (within the Högskoleförberedande examen for arithmetic, algebra and geometry) is expected prior to starting the IB DP Mathematics HL course, otherwise teachers should ensure this is included in the course at an early stage.

Three areas of the Swedish course that are not explicitly referenced in the IB DP Mathematics SL course (and are therefore identified as “partially included” in the IB DP) are those related to the concept of polynomial, properties of the equation of a circle, and secant.

As found with the IB DP Mathematics HL course, the Högskoleförberedande examen content for problem solving is fully included in the IB DP Mathematics SL course. For example, the Swedish content related to digital media and tools and applications of mathematical problems in other subjects is found within both the IB DP Mathematics SL and the IB DP Mathematics HL course (e.g. using both formula and technology in algebra, and applying algebra to compound interest and population growth).

In regard to mathematical problems related to the cultural history of mathematics, the IB DP Mathematics SL course refers to Pythagoras' theorem and encourages students to question who really invented it (Topic 3 – Circular functions and trigonometry Links section for aim 8). Also, in acknowledging that trigonometry was developed by successive civilisations, discussion on how mathematical knowledge is considered from a sociocultural perspective is encouraged (Topic 3 – Circular functions and trigonometry Links section for theory of knowledge).

*Comparative analysis of IB Mathematical Studies SL course to Högskoleförberedande examen Mathematics 3c*

The main area in which the IB DP Mathematical Studies SL course satisfies the content of the Högskoleförberedande examen Mathematics 3c course is in relation to problem-solving. For example, students taking the IB DP Mathematical Studies SL course are encouraged to:

- Use technology to find the gradient of a point (Topic 7 – Introduction to differential calculus)
- Calculate compound interest and annual depreciation (Topic 1 – Number and algebra)
- Solve problems that may incorporate Pythagoras' theorem whose early diagrams occur in Chinese and Indian manuscripts (Topic 5 – Geometry and trigonometry Links section for international mindedness).

One sub-topic from the Swedish topic on arithmetic, algebra and geometry is similarly included in the IB DP; both courses similarly cover use of cosine, sine and area theorems for an arbitrary triangle. However, the other arithmetic, algebra and geometry content from the Högskoleförberedande examen 3c course are not evident in the IB DP Mathematical Studies SL course.

Some of the Högskoleförberedande examen content taught under the topic of relationships and change is included or partially included within the IB DP Mathematical Studies SL course. For example, both courses cover algebraic and graphical methods for determining the value of a function. In three other areas, such as the orientation to continuous and discrete functions as well as the concept of limits, the Högskoleförberedande examen content is partially included in the IB DP Mathematical Studies SL course. In this example, the concept of limits is not explicitly evidenced in the context of continuous and discrete functions. Further, the IB DP Mathematical Studies SL course includes tangent and the concept of derivative of a function and as a rate of change, although there is no reference to the concept of secant. The remaining six areas of the Högskoleförberedande examen content for relationship and change are not included in the IB DP Mathematical Studies SL course.

## IB DP Mathematics and Högskoleförberedande examen Mathematics 4 course content comparison

The Högskoleförberedande examen Mathematics 4 course covers the same three main topics as those in the Mathematics 3c course; however the sub-topics demonstrate the progression in the level and content.

**Table 24: Content comparison of the IB DP Mathematics and Högskoleförberedande examen Mathematics 4 course**

| Högskoleförberedande examen - Mathematics 4 | | Included in the IB DP Mathematics HL | Included in the IB DP Mathematics SL | Included in the IB DP Mathematical Studies SL |
|---|---|---|---|---|
| **Arithmetic, algebra and geometry** | Methods of calculating complex numbers written in different forms including rectangular and polar forms | ✓ | | |
| | The complex number plane, representation of complex numbers as points and vectors | ✓ | | |
| | Conjugates and absolute amounts of a complex number | ✓ | | |
| | Use and proof of de Moivre's formula | ✓ | | |
| | Algebraic and graphical methods for solving simple polynomial equations with complex roots and real polynomial equations of higher degrees, also by means of the factor theorem | ✓ | | |
| | Handling trigonometric expressions, and proof and use of trigonometric formulae including the Pythagorean trigonometric identity and the addition formulae | ✓* | ✓* | |
| | Algebraic and graphical methods for solving trigonometric equations | ✓ | ✓* | |
| | Different methods of proof in mathematics, with examples from the areas of arithmetic, algebra or geometry | ✓ | | |
| **Relationships and change** | Properties of trigonometric functions, logarithmic functions, compound functions and absolute amounts as functions | ✓ | ✓* | |
| | Drawing graphs and their related asymptotes | ✓ | ✓ | ✓ |
| | Derivation and use of the rules of derivation for trigonometric, logarithmic, exponential and compound functions, and also the | ✓ | ✓ | |

| Högskoleförberedande examen - Mathematics 4 | | Included in the IB DP Mathematics HL | Included in the IB DP Mathematics SL | Included in the IB DP Mathematical Studies SL |
|---|---|---|---|---|
| | product and quotients of functions | | | |
| | Algebraic and graphical methods for determining integrals with and without digital tools, including estimates of magnitudes and probability distribution | ✓ | ✓* | |
| | The concept of differential equations and their properties in simple applications that are relevant to subjects typical of programmes | ✓ | | |
| **Problem solving** | Strategies for mathematical problem solving including the use of digital media and tools | ✓ | ✓ | ✓ |
| | Mathematical problems of importance in societal life and applications in other subjects | ✓ | ✓ | ✓ |
| | Mathematical problems related to the cultural history of mathematics. | ✓ | ✓ | ✓ |

The Högskoleförberedande examen Mathematics 4 course is best covered by the IB DP Mathematics HL course, with some content also included at Mathematics SL. The IB DP Mathematical Studies SL course has few topic areas in common with the Högskoleförberedande examen Mathematics 4 with the exception of the Swedish Problem Solving topics which are well covered in all three IB DP Mathematics courses.

*Comparative analysis of IB Mathematics HL course to Högskoleförberedande examen Mathematics 4*

Analysis of the IB DP Mathematics HL course specification reveals similar content to that included in the Högskoleförberedande examen Mathematics 4 course. Nearly all of the content in the Högskoleförberedande examen Mathematics 4 course can be considered fully included in the IB DP Mathematics HL course. It is observed that both courses cover complex numbers, polar form, de Moivre's formula, the concept of proof, derivation, and differential equations.

As with the Högskoleförberedande examen Mathematics 3c course, the Mathematics 4 course includes the same content related to problem solving. Therefore, as with the previous Mathematics 3c comparison, the IB DP Mathematics HL course fully includes the Högskoleförberedande examen Mathematics 4 problem solving content.

One area of the Högskoleförberedande examen Mathematics 4 course observed to be partially covered by the IB DP is related to the addition formulae within trigonometry.

*Comparative analysis of IB Mathematics SL course to Högskoleförberedande examen Mathematics 4*

Some content within the Högskoleförberedande examen Mathematics 4 course is similarly included or partially included within the IB DP Mathematics SL course. Most of the areas found not to be included are related to arithmetic, algebra and geometry. For example, there is no reference to complex numbers or de Moivre's formula in the IB DP Mathematics SL course. The other content areas within the Mathematics 4 arithmetic, algebra and geometry topic, however, are considered partially included. For example, both cover the Pythagorean trigonometric identity and solving trigonometric equations but these are not used in the same context in both courses.

The Högskoleförberedande examen's Mathematics 4 content for relationship and change is mainly fully included in the IB Mathematics SL course (i.e. drawing graphs and their related asymptotes) or partially included (i.e. logarithmic functions and compound functions is included in the IB DP but trigonometric functions are not included). However, the Swedish course's content related to differential equations is not included in the IB DP Mathematics SL course.

Both programme also similarly cover content related to problem solving, as discussed in the Mathematics HL comparison, and with the Swedish Mathematics 3c course.

*Comparative analysis of IB Mathematical Studies SL course to Högskoleförberedande examen Mathematics 4*

With the exception of the Högskoleförberedande examen Mathematics 4 course content for problem-solving (which is the same as the Högskoleförberedande examen Mathematics 3c course) and drawing graphs and their related asymptotes, there is no evidence that the IB DP Mathematical Studies SL course includes the other content areas of the Högskoleförberedande examen Mathematics 4 course.

### IB DP Mathematics and Högskoleförberedande examen Mathematics 5 course content comparison

The topics and sub-topics of the Högskoleförberedande examen Mathematics 5 course are presented in the table below. All three IB DP mathematics courses (Mathematics HL and SL and Mathematical Studies SL) have been compared to Mathematics 5 within the table; however the analysis below has focussed on the Mathematics HL, as Mathematics SL and Mathematical Studies SL demonstrated few topics in common with the previous Mathematics 4 course.

**Table 25: Content comparison of the IB DP Mathematics and Högskoleförberedande examen Mathematics 5 course**

| Högskoleförberedande examen - Mathematics 5 | | Included in the IB DP Mathematics HL | Included in the IB DP Mathematics SL | Included in the IB DP Mathematical Studies SL |
|---|---|---|---|---|
| **Relationships and change** | Strategies to set up and interpret differential equations as models for real situations | ✓ | | |
| | Use and solution of differential equations with digital tools in various fields which are relevant to subjects typical of programmes | ✓* | | |
| **Discrete mathematics** | The concept of number, operations on sets, set theory notation and Venn diagrams | Expected Prior Learning | Expected Prior Learning | ✓* |
| | The concept of congruence of integers and calculating congruence | ✓ | | |
| | The concept of permutations and combinations | ✓ | | |
| | Methods of calculating the number of combinations and permutations, and reasoning over the validity of methods | ✓* | | |
| | The concept of graphs, different types of graphs and their properties, and some well-known problems from graphical theory | ✓ | ✓* | ✓* |
| | The concept of recursion and sequence | ✓ | ✓* | ✓* |
| | Mathematical induction with concrete examples from e.g. the area of number theory. | ✓ | | |
| **Problem solving** | Strategies for mathematical problem solving including the use of digital media and tools | ✓ | ✓ | ✓ |
| | Wide ranging problem situations in subject typical of a programme which also deepen knowledge of integrals and derivatives. The opportunities and limitations of Mathematic in these situations | ✓* | ✓* | |
| | Mathematical problems related to the cultural history of mathematics. | ✓ | ✓ | ✓ |

The IB DP Mathematics HL course includes, whether fully or partially, all of the topics of the Högskoleförberedande examen Mathematics 5 course and is the most similar to it out of the three IB DP Mathematics courses. Excluding the Swedish topic on Problem Solving, which is mostly included in all three IB DP Mathematics courses, the IB DP Mathematics SL and Mathematical Studies SL courses have few topics in common with the Swedish course.

*Comparative analysis of IB Mathematics HL course to Högskoleförberedande examen Mathematics 5*

The content of the IB Mathematics HL course compares well to the Högskoleförberedande examen Mathematics 5 course overall, with most of the content areas fully covered. For example, recursion and sequence are clearly included in the IB Mathematics HL optional Topic 10 for discrete mathematics. Permutations and combinations are included in the optional topic for sets, relations and groups (Topic 8). In addition, reference to 'handshaking lemma' confirms IB DP Mathematics HL coverage of graphical theory.

For the areas partially included in the IB DP Mathematics HL course, certain aspects of the Högskoleförberedande examen are not explicitly evidenced. These are:

- Using digital tools in various fields relevant to subjects typical of a programme (for the purpose of solving differential equations)
- Reasoning over the validity of methods (for the purposes of calculating the number of combinations and permutations)
- Wide ranging problem situations in subjects typical of a programme (for the purposes of deepening knowledge of integrals and derivatives), and the opportunities and limitations of mathematics in these situations.

The concept of number, operations on sets, set theory notation and Venn diagrams in the Högskoleförberedande examen is expected to be known prior to starting the IB DP Mathematics HL course. However, if these are unknown prior to the IB DP Mathematics HL course, teachers must include them at an early stage.

*Comparative analysis of IB Mathematics SL and Mathematical Studies SL courses to Högskoleförberedande examen Mathematics 5*

As demonstrated in the table above, only a few content areas were found to be included or partially included in the Mathematics SL and Mathematical Studies SL courses. As with the previous Högskoleförberedande examen Mathematics 3c and 4 courses, some content areas from the problem solving topic can be found within the IB DP courses. The remaining content areas that are considered partially included are those covering basic mathematics topics such as graphs, sequences, concept of number and Venn diagrams; however the overall topic of discrete mathematics is not included within the IB DP Mathematics SL or Mathematical Studies.

## 3.4 Research Question 4: Subject Assessment and Cognitive Demand

**In what ways do the DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL approaches to assessment align or differ with equivalent Swedish upper secondary subjects? Are there differences in the cognitive demand between DP Mathematics SL and HL, Mathematical Studies SL and Sciences (Biology, Chemistry and Physics) SL; and equivalent Swedish upper secondary schools?**

As outlined in the methodology, assessment in the Swedish upper secondary school (higher education preparatory) programmes are entirely internally developed and assessed at school level, with no overarching structure or format prescribed to schools in Sweden. By contrast, in the IB DP, written assessments are developed and assessed externally; an internally-assessed investigation is also conducted but assessment criteria guidance is developed externally. A summary of the IB DP assessment methods and structure can be found in Appendix 2. In the absence of sample assessment or guidance on assessment methods in Sweden, the following analysis has focussed on the Swedish course *Knowledge Requirements* which are prescribed nationally and used by teachers to determine the appropriate grade to award students (Skolverket, 2012).

### 3.4.1 Biology, Chemistry, and Physics

As the Högskoleförberedande examen knowledge requirements are largely the same across Biology 2; Chemistry 2; and Physics 2, and the IB DP prescribes the same assessment objectives, assessment criteria and assessment methods across all science subjects, the following section examines the science subjects together. Examples have been drawn across all science subjects in the IB DP.

Assessment and cognitive demand

The assessment objectives for the IB DP Science SL courses (the assessment objectives are repeated across the science subjects) can be seen in the table below.

**Table 26: IB DP assessment objectives**

| IB DP Assessment Objectives |
|---|
| 1) Demonstrate knowledge and understanding of:<br>a. facts, concepts, and terminology<br>b. methodologies and techniques<br>c. communicating scientific information.<br>2) Apply:<br>a. facts, concepts, and terminology<br>b. methodologies and techniques<br>c. methods of communicating scientific information.<br>3) Formulate, analyse and evaluate:<br>a. hypotheses, research questions and predictions<br>b. methodologies and techniques<br>c. primary and secondary data<br>d. scientific explanations. |

| IB DP Assessment Objectives |
|---|
| 4) Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations. |

In the Högskoleförberedande examen, knowledge requirements are provided at Grade E, C, and A. As Grade E should demonstrate the requirements to pass the course and Grade A should demonstrate the minimum expectations to receive the highest grade, these have been presented in the table below. For the purposes of this section, the Biology 2 knowledge requirements have been illustrated below; the knowledge requirements for Physics 2 and Chemistry 2 (highlighting any differences found in the requirements) can be found in Appendix 3.

**Table 27: Högskoleförberedande examen Biology 2 Grade E and Grade A knowledge requirements**

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| Students give an account **in basic terms** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with some certainty** to find answers to questions, and also to describe and **illustrate** biological relationships at different levels, from molecular level to ecosystem level. Based on **some** example, students give an account **in basic terms** of how the models and theories of biology are developed. | Students give an account **in detail and in a balanced way** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with certainty** to look for answers to issues, and to **describe and generalise** biological relationships at different levels, from the level of molecules to that of ecosystems. Based **on some examples** students give an account **in detail and a balanced way** of how the theories and models of biology are developed. |
| Students also evaluate the validity of the models and theories and their limitations in **simple** assessments. | Students also assess the validity and limitations of models and theories in **balanced** assessments. |
| Students analyse and look for answers to **simple** questions in **familiar situations** with **satisfactory** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with some certainty** their own issues. Students plan and carry out **in consultation** with the supervisor experiments and field studies in a satisfactory way. In addition, students handle materials and equipment safely. Furthermore, students interpret their results, evaluate their methods in **simple** assessments and give the reasons for their conclusions with simple reasoning. | Students analyse and look for answers to **complex** questions in **familiar and new situations** with **good** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with certainty complex** issues. Students plan and carry out **after consultation** with the supervisor experiments and field studies in a satisfactory way. In addition, students handle materials and equipment safely. Furthermore, students interpret their results, assess their methods in **balanced** assessments and give reasons for their conclusions with **well grounded and balanced** reasoning. **Where necessary, students also propose changes.** |
| Students discuss in **basic terms** issues concerning the importance of biology for the individual and society. In their discussions, students put forward **simple** arguments and give an account **in basic terms** of the consequences of **some** possible viewpoints. | Students **discuss in detail and in a balanced way complex** issues concerning the importance of biology for the individual and society. In their discussions, students put forward **well grounded and balanced** arguments and give an account **in detail and in a balanced way** of the consequences of **several** possible viewpoints. **Students also propose new issues for discussion.** |

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| Students use **with some certainty** the language of science and adapt **to some extent** their communication to purpose and context. In addition, students use different types of sources and make **simple** assessments of the credibility and relevance of their sources and information. | Students use **with some certainty** the language of science and adapt **to a great extent** their communication to purpose and context. Students use different types of sources and make **well grounded and balanced** assessments of the credibility and relevance of their sources and information. |
| In consultation with the supervisor, students assess **with some certainty** their own ability and the requirements of the situation. | In consultation with the supervisor, students assess **with certainty** their own ability and the requirements of the situation. |

As seen in the above table, the Swedish science courses require that students are able to demonstrate basic knowledge of concepts and theories in the subject studied. Recall and understanding of basic facts, concepts, and knowledge related to science is similarly expected in both courses; the IB DP tests students core knowledge and Assessment Objective 1, which refers to knowledge and understanding, through all three external assessments and the internal assessments. In the IB DP Paper 1, multiple-choice questions are used to assess this knowledge; examples of these questions are provided below:

**Figure 7: IB DP Biology SL Paper 1 sample questions**

3. What is the approximate thickness of the plasma membrane of a cell?

A.10 μm

B. 50 μm

C.10 nm

D. 50 nm

6. Cyclins were discovered by Timothy R Hunt in 1982 while studying sea urchins.

What is a function of cyclins?

A. Circulation of seawater for gas exchange

B. Rotation of tentacles

C. Control of the cell cycle

D. Recycling of nutrients

Knowledge and application of relevant mathematics to solve problems is also similarly expected in both courses, as appropriate for each subject. For example, the IB DP Physics SL Paper 1 assesses these skills within the following questions:

**Figure 8: IB DP Physics SL Paper 1 sample questions**

1. An object falls freely from rest through a vertical distance of 44.0 m in a time of 3.0 s. What value should be quoted for the acceleration of free-fall?

   A. 9.778 m s –2
   B. 9.780 m s –2
   C. 9.78 m s –2
   D. 9.8 m s –2

3. A woman walks due north at 1 m s –1 before turning through an angle of 90 to travel due east without any change in speed. What is the change, if any, of her velocity?

   A. No change
   B. –1 1ms to the west
   C. –1 2 ms to the north east
   D. –1 2 ms to the south east

The remaining IB DP external assessments use a combination of short and extended answer questions that test the core and optional content taught during the course with students tested on Assessment Objective (AO) 1-3.

As identified within the knowledge requirements, Swedish students are expected to describe their knowledge in basic terms for a Grade E or in detailed terms for a Grade A. Further, in regards to issues about the individual and society, Grade A students are expected to discuss **complex issues**. Within the IB DP, Paper 2 and 3 require short and extended responses to questions, students can answer some of these questions in “basic terms” for full or partial marks, but many questions will require “detailed terms” as they require students to “explain” a concept or process, or to “compare” two ideas. No direct questions about “the individual and society” were found in the IB DP, but Paper 2 and 3 in Chemistry and Biology include questions that require the student to ‘discuss’. Further, it is possible that this theme is indirectly tested within the assessments; for instance, in IB DP Biology SL there are questions related to human biology and real-life experimental scenarios or issues regarding effects to animals or the atmosphere. Further, in Chemistry, this could be indirectly tested in the following question from Paper 3 Option A Materials:

**Figure 9: IB DP Chemistry SL Paper 3 sample question**

6. Plastics, such as PVC and melamine, are widely used in modern society.

   (a) PVC is thermoplastic, whereas melamine is thermosetting. State one other way in which scientists have tried to classify plastics, and outline why the classification you have chosen is useful.

   (b) It was almost a century after the discovery of PVC before Waldo Semon turned it into a useful plastic by adding plasticizers. State and explain the effect plasticizers have on the properties of PVC.

   (c) Justify why, in terms of atom economy, the polymerization of PVC could be considered “green chemistry”.

   (d) In spite of the conclusion in part (c), many consider that PVC is harmful to the environment. Identify one specific toxic chemical released by the combustion of PVC.

Further, this knowledge requirement could be similarly assessed within the IB DP Group 4 project which occurs within all three science courses and "is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10—that is, to "develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge"". Further, the Group 4 project may involve use of secondary data sources or data from other sources which broadly compares with the Swedish knowledge requirement for students to demonstrate their ability to use different sources and assess their credibility and relevance.

Application skills are also referenced in the Högskoleförberedande examen knowledge requirements; at Grade E Swedish students are able to use their knowledge with "some certainty" however at Grade A they have "certainty". The IB DP also assesses application skills as indicated in the Assessment Objective 2 (AO2); this applies to application of facts, concepts, and terminology in addition to methodologies and techniques. AO2 is assessed within all three IB DP external assessments and the internal assessment. Although the students' level of certainty is not directly measured within these assessments, students do however need to apply their knowledge accurately in order to pass the examination; therefore "some certainty" in their response may not lead to a passing grade in the IB DP. For example, in the IB DP Chemistry SL assessments, two different questions require students to "apply IUPAC rules" in order to state the name of a chemical or compound.

Students in both courses are expected to be able to evaluate. Within the Swedish knowledge requirements, students are expected to be able to evaluate whether models or theories are valid and provide "simple assessments" (i.e. an explanation with little to no detail) at Grade E and "balanced assessments" (i.e. an evaluation that contains detail and multiple perspectives (Skolverket, 2012)) at Grade A. Within the IB DP questions asking students to evaluate can be found within the written assessments and internal assessment; however these are regarding a wide range of knowledge and topic areas beyond the validity or limitations of models and theories. For example, IB Biology SL Paper 2 includes the following question:

**Figure 10: IB DP Biology SL Paper 2 sample questions**

6. Antibiotics can be used to treat bacterial infections in human tissues because of differences in cell structure between prokaryotes and eukaryotes.

(a) Distinguish between the structure of prokaryotes and eukaryotes. [8]

(b) Evaluate the drug tests that Florey and Chain carried out on penicillin. [3]

(c) Explain the reasons for the ineffectiveness of antibiotics in the treatment of viral diseases. [4]

The expectations for Swedish students to know how models and theories were developed, evaluate the validity of models, and understand the consequences of different viewpoints are not directly assessed within the IB DP. This reflects a minor difference in the focus of the Swedish courses in comparison to the IB DP. However, it is possible that this topic could indirectly be assessed within the IB DP sciences, as demonstrated in the below question from IB DP Physics SL Paper 3 (optional topic A on Relativity):

*4.a Einstein discovered a discrepancy, related to the speed of light, between Maxwell's equations of electromagnetism and Newtonian mechanics. Outline the discrepancy and how Einstein dealt with it.*

One section of the Högskoleförberedande examen knowledge requirements gives an indication of question types. In particular, at Grade E students are able to "analyse and look for answers to **simple** questions in **familiar situations** with **satisfactory** results". The IB DP sciences Paper 1 includes multiple-choice questions that are based on core topics in the subject, and it is likely that some of the questions are provided in a familiar context; however Papers 1-3 also include more complex questions based on unfamiliar scenarios or information such as the one provided from IB DP Biology Paper 3 below:

**Figure 11: IB DP Biology SL Paper 3 sample questions**

1. Photosynthesis rates were determined in young kerosene trees (Copaifera langsdorffii) under sunny or shaded conditions and in dry or rainy conditions.

| | Dry conditions | | Rainy conditions | |
|---|---|---|---|---|
| | Sun | Shade | Sun | Shade |
| Light intensity / mol photons $m^{-2}$ $day^{-1}$ | 51.0 | 5.5 | 58.7 | 2.8 |
| Net photosynthesis / mol $CO_2$ $m^{-2}$ $day^{-1}$ | 101.6 | 36.1 | 285.4 | 62.4 |

[Source: adapted from C C Ronquin, *et al.*, (2009), *Brazilian Journal of Plant Physiology*, **21** (3), pages 197–208]

(a) Using the table, identify the conditions that result in the highest rate of photosynthesis. [1]

(b) Suggest which factor is limiting photosynthesis in young kerosene trees that were in rainy conditions in the sun. [1]

(c) Describe a method for measuring the rate of photosynthesis in aquatic plants. [3]

This and similar questions in the IB DP are more complex and are similar to the higher order thinking skills expected at Grade A in the Högskoleförberedande examen for students to be able to "analyse and look for answers to complex questions in familiar and new situations with good results".

Much of the Swedish knowledge requirements apply to a practical context with the student engaging in practical work and applying their practical skills. They are assessed on their ability to formulate hypotheses, plan and conduct experiments, interpret their results, and provide justification for their conclusions. Further they must use different sources (presumably for research rather than data sources) and evaluate the credibility of the sources and information. They must be able to determine and evaluate their ability to complete such tasks and the full requirements of the situation (presumably the experiment or practical setting) they are engaged in. The IB DP students are also assessed on these skills, and in many cases through the internal assessment.

Higher order thinking skills are expected within the practical context as well. This is found in the Högskoleförberedande examen for students to "formulate relevant hypotheses and formulate **with some certainty** their own issues" at Grade E; however at Grade A they

"formulate **with certainty complex** issues". The formulation of hypotheses is also expected in the IB DP within Assessment Objective 3 (AO3). This is assessed in questions that ask students to 'suggest' such as the following from the IB DP Biology SL Paper 3:

> *(ii) Suggest reasons for the change in species diversity after removal of the sea star. [3]*

Further, in the Swedish course students are expected to be able to "propose changes" and to "propose new issues for discussion"; these are skills that are only expected of Grade A students. As seen above, the IB DP assesses these within AO3 and expects students to formulate research questions, predictions, and scientific explanations; however these skills are expected of students at all achievement levels in the IB DP. A variety of questions could allow students to propose their own ideas, including the following from the IB DP Biology SL Paper 2:

**Figure 12: IB DP Biology SL Paper 2 further sample questions**

1. The research described in this question was strongly criticized soon after it was published by some other biologists and by the company that produced *Bt* varieties of crop plants. In particular there were objections to a statement in the research paper that "Widespread planting of *Bt* crops has unexpected ecosystem-scale consequences".

   (g) Discuss whether this statement in the research paper was justified, based on the methods used in the research and the data obtained. [3]

4. The diagram shows the carbon cycle.

   (b) Predict the conditions that would increase the release of methane shown at Z. [2]

7. Humans need a supply of energy for processes such as active transport in cells.

   (a) Explain how humans release energy from digested foods to make it available for processes in cells. [7]

   (b) Describe one example that occurs in axons for each of the following
   - active transport
   - and facilitated diffusion. [5]

   (c) Outline how biologists can ensure that research into energy release involving animals is ethically acceptable.

Further the IB DP internal investigation assessment allows students to demonstrate higher order thinking skills. The internal assessment requires that students complete a scientific investigation over a period of 10 hours and a 6-12 page write-up on the investigation. Students are then assessed based on the following assessment criteria:

- Personal engagement
- Exploration
- Analysis
- Evaluation
- Communication.

The IB DP internal assessment tests all four assessment objectives and similar knowledge requirements to the Swedish programme. In addition to formulating hypotheses, both

programmes require that students are able to demonstrate their ability to plan and conduct experiments, assess results, and provide justifications for their conclusions. Although both programmes discuss the level of supervision or guidance provided by the student's supervisor or teacher, the Swedish programme expects Grade E students to carry out experiments "in consultation with" the supervisor rather than independently; alternatively, the IB DP Personal Engagement criterion expects students at the lowest grade to have demonstrated little independent thinking or initiative in their investigation. Further, the analysis criterion examines how well students are able to interpret the data and draw a valid and detailed conclusion. The Evaluation criterion examines how well the student describes and justifies their conclusion and examines their ability to identify any limitations in the data, sources of error, and methodological issues.

The IB DP internal assessment criteria also demonstrate that knowledge and application of subject specific terminology is required to receive a high grade (many errors result in a low mark for this specific assessment criteria "Communication"). The Swedish programme expects students to "use with some certainty the language of science and adapt to some extent their communication to purpose and context."

The final Swedish knowledge requirement is for students to assess their own ability. Although this is not an assessment objective or task, reflection is a key goal of the IB DP and one of the attributes of the IB learner profile (i.e. "We work to understand our strengths and weaknesses in order to support our learning and personal development"). Further, the theory of knowledge course, which is linked to all subjects the students takes, aims to engage students in reflecting on their knowledge.

### 3.4.2 Mathematics

Assessment and cognitive demand

As previously discussed, the Högskoleförberedande examen does not set external assessment for the courses reviewed in this study (including Mathematics 3c, 4 and 5) nor is there a prescribed format for internal assessment. The IB, however, employs both external assessment and internal assessment for the DP which, whilst conducted by IB World Schools, must fulfil the requirements set out by the IB. A combination of assessment methods is used as follows:

- IB DP Mathematics HL: three externally-assessed written examinations and an internally-assessed (but externally set) mathematical exploration
- IB DP Mathematics SL: two externally-assessed written examinations and an internally-assessed (but externally set) mathematical exploration
- IB DP Mathematical Studies SL: two externally-assessed written examinations and a project.

All of the above IB DP assessments consist of short and extended response questions. Calculators are also used in all IB DP courses, but both the IB DP Mathematics HL and SL each have one paper where a calculator is not allowed.

The IB DP prescribes broadly the same assessment objectives for IB DP Mathematics HL and SL and Mathematical Studies SL; any minor differences have been highlighted in the table below (i.e. HL and SL only, and Mathematical Studies SL only):

**Table 28: IB DP Mathematics Assessment Objectives**

| IB DP Assessment Objectives |
|---|
| 1) Knowledge and understanding: recall, select and use their knowledge of mathematical facts, concepts and techniques in a variety of familiar and unfamiliar contexts<br>2) Problem-solving: recall, select and use their knowledge of mathematical skills, results and models in both real and abstract contexts to solve problems<br>3) Communication and interpretation: transform common realistic contexts into mathematics; comment on the context; sketch or draw mathematical diagrams, graphs or constructions both on paper and using technology; record methods, solutions and conclusions using standardized notation<br>4) Technology: use technology, accurately, appropriately and efficiently both to explore new ideas and to solve problems<br>5) Reasoning: construct mathematical arguments through use of precise statements, logical deduction and inference, and by the manipulation of mathematical expressions<br>6) Investigative approaches: investigate unfamiliar situations, *both abstract and real-world* involving organizing and analysing information or measurements, *making conjectures* drawing conclusions, testing their validity, *and considering their scope and limitations*. |

As with the science subjects, the mathematics courses of the Högskoleförberedande examen are graded using a letter-based system of A-E where grade A is the highest passing grade and E is the lowest. Knowledge requirements are specified in depth at grades A, C and E and these are the same across the three Swedish courses examined and researched in this study (i.e. Mathematics 3c, Mathematics 4 and Mathematics 5). The below table demonstrates the requirements for the Grade E and the Grade A; these indicate the requirements to pass the course and the minimum expectations to receive the highest grade, respectively.

**Table 29: Högskoleförberedande examen Mathematics Grade E and Grade A knowledge requirements**

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| Students can **in basic terms** describe the meaning of key concepts using **some** representations and **in basic terms** describe relationships between the concepts. In addition, students switch **with some certainty** between different representations. Students can **with some certainty** use concepts and relationships between concepts to solve mathematical problems and problem situations in subjects typical of a programme **in familiar situations**. In their work students handle **some simple** procedures, and solve tasks of a standard nature **with some certainty**, both with and without digital tools. | Students can **define and in detail** describe the meaning of key concepts using **several** representations and **in detail** describe relationships between the concepts. In addition, students switch **with certainty** between different representations. Students can **with certainty** use concepts and relationships between concepts to solve **complex** mathematical problems and problem situations in subjects typical of a programme. In their work students handle **several** procedures, **including advanced and algebraic expressions**, and solve tasks of a standard nature **with certainty and in an effective way**, both with and without digital tools. |
| Students can formulate, analyse and solve | Students can formulate, analyse and solve |

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| mathematical problems **of a simple nature**. These problems involve **a few concepts** and require **simple** interpretations. In their work students re-express and transform realistic problem situations into mathematical formulations by applying **given** mathematical models. Students can in a **simple** assessment evaluate the plausibility of their results, and also that of selected models, strategies and methods. | mathematical problems **of a complex nature**. These problems involve **several** concepts and require **advanced** interpretations. **In problem solving, students discover general relationships that are presented in symbolic algebra**. In their work students re-express and transform realistic problem situations into mathematical formulations by **choosing**, applying **and adapting** mathematical models. Students can in a **balanced** assessment evaluate the plausibility of their results, and also that of selected models, strategies, methods **and their alternatives.** |
| Students can apply **simple** mathematical reasoning and evaluate in **simple** assessments their own reasoning and that of others, and differentiate between guesses and well-grounded statements. In addition, students express themselves **with some certainty** in speech and writing **with elements of** mathematical symbols and other representation. | Students can apply **well grounded and balanced** mathematical reasoning, evaluate in **balanced** assessments **and further develop** their own reasoning and that of others, and differentiate between guesses and well grounded statements. **Furthermore, students can carry out mathematical proofs.** In addition, students can express themselves **with certainty** in speech and writing **and use** mathematical symbols and other forms of representation **with good adaptation to purpose and situation.** |
| By giving examples students relate something in **the course content** to its importance in other subjects, professional, societal life, and to the cultural history of mathematics. In addition, students can apply **simple** reasoning to the relevance of the examples. | By giving examples, students relate something in **some of the course's sub-areas** to its importance in other subjects, professional, societal life and to the cultural history of mathematics. In addition, students can apply **well grounded and balanced** reasoning to the relevance of the examples. |

As seen in the tables above, both the IB DP and Swedish courses require students to have knowledge and understanding of mathematics concepts. For example, the Swedish knowledge requirements state that students must be able to describe the meaning of key concepts and the relationships between them, with a higher level of detail required for the higher grade. Further, students use either some representations at Grade E or several representations at Grade A in these descriptions.

As an example of knowledge of key concepts, the IB DP Mathematics HL programme includes concepts of a vector and representation of vectors. Mathematical reasoning is assessed in the IB DP Mathematics HL and SL specimen examination papers analysed in this study. Furthermore, both IB DP Mathematics HL and SL specimen examination papers assess student's ability to use models to solve particular problems.

This is similarly assessed within all of the IB DP courses within Assessment Objective 1 (AO1) regarding knowledge and understanding of mathematical concepts; however rather than specify the level of detail that students provide, the AO states that students can use these in a variety of familiar and unfamiliar contexts. Further, the IB DP courses are more focussed on problem solving and application of mathematics rather than recall of definitions,

therefore no question tasks are specifically targeted at assessing understanding of definitions or demonstration of different representations knowledge in the IB DP.

In addition to the above, the IB DP Mathematics HL and SL courses demonstrate further similarities with the Swedish course knowledge requirements on knowledge and understanding. In particular, the IB DP Mathematics HL and SL mathematical exploration assessment criterion Mathematical Presentation looks at how well the student is able to use mathematical representations, terms and mathematical language; but this is more focussed on the appropriate usage of the representations rather than the frequency, quantity, or ability to switch between representations.

As seen in the Swedish courses, students are required to use their knowledge to solve problems with some certainty in familiar situations for a Grade E, or with certainty and on more complex problems for a Grade A. Problem-solving is similarly expected of IB DP students as set out in AO2 and tested throughout the assessments. Short or extended answer questions are used to assess this in the IB DP.

In terms of the types of problems solved, the Swedish course requires that students handle procedures and solve tasks with and without tools such as calculators. At Grade E, simple procedures are expected, and they are solved with some certainty; however Grade A students are expected to be able to handle several procedures, including advanced and algebraic expressions and to do so effectively and with certainty. Manipulation of mathematical expressions is similarly expected in all IB DP courses, as specified in AO5; however it is unclear if this is the same expectation for Swedish students to do “advanced expressions”.

Like the Swedish course, use of digital tools, such as calculators, is expected of students at all performance levels in the IB DP courses. This is demonstrated in AO4 regarding technology; however whereas the IB DP Mathematics HL and SL both include an examination where calculators are not permitted, the Mathematical Studies SL course allows calculators throughout all the assessment.

In general, all Swedish students are expected to be able to formulate, analyse and solve, at a minimum, simple (Grade E) mathematical problems and do interpretations. These become more complex or advanced at Grade A. Problem-solving (AO2) and Investigative approaches (AO6) are similarly assessed within all of the IB DP courses; IB DP students are assessed on their ability to analyse information and to solve problems within all of their assessments. The internally-assessed mathematical exploration in the IB DP Mathematics HL and SL programmes also requires that students formulate, analyse and solve mathematical problems independently, in doing so appreciating the application of mathematics. They also facilitate written expression, including mathematical presentation, and personal reflection. Further, IB DP students are required to interpret, as demonstrated in AO3.

Similar skills are also required in the IB DP Mathematical Studies SL course. For example, in the internally-assessed project work students are required to formulate, analyse and solve mathematical problems independently, appreciating the application of mathematics in doing so. They also facilitate written expression, including mathematical presentation, and assess

students' interpretation of results and students' awareness of the validity of techniques / methods used and/or conclusions made. However, in regard to the threshold requirement in the Swedish courses for students to express themselves in speech, IB DP Mathematical Studies SL students are only required to give a class presentation on their project as a way of the teacher checking it's all the students' own work.

With regard to evaluating the plausibility of selected models in the Swedish courses, the IB DP Mathematics SL specimen Paper 2 provides an example, in which one question (question 8c) asks students to comment on the appropriateness of using a model to estimate a factory's production costs of certain quantities of boxes.

Application of mathematical models is required in both the Swedish courses and the IB DP Mathematical Studies SL course. For example, Paper 1 of the Mathematical Studies SL specimen examination asks students to use a given model to predict the temperature of a liquid so many seconds after the start of heating. Mathematical reasoning is also evident, for example in the Mathematical Studies SL specimen examinations which asks students' their reasons for particular conclusions or argument validity in given situations.

At Grade A only, Swedish students are expected to be able to do the following:

- In problem solving, students discover general relationships that are presented in symbolic algebra
- Carry out mathematical proofs
- Use mathematics symbols and other forms of representation with good adaptation to purpose and situation.

All of the IB DP students are expected to be able to communicate (AO3) which includes the use of mathematical representations. Proofs are also assessed in the IB DP, but mostly within the Mathematics HL and SL as identified from the content comparison. Without examples of the "discovery of general relationships" in practice in the Swedish courses it is difficult to establish whether the IB DP Mathematics HL and SL and the Swedish courses both similarly assess this.

Communication, in particular using mathematical symbols and expressions in speech and writing is further emphasised in the Swedish course knowledge requirements. In addition to AO3, mentioned above, the IB DP courses require students to demonstrate written communication of mathematical thinking through the internal assessments. Oral communication is not explicitly referenced; however the Mathematics HL and SL and Mathematical Studies SL courses require students to discuss their mathematical exploration/project with teachers in the classroom.

Another key skill, reasoning, is similarly expected in all of the IB DP and Swedish courses. This is demonstrated in the IB DP AO5, and in the Swedish courses requirement for students to be able to apply mathematical reasoning, evaluate their own reasoning and the reasoning of others. Further, in the IB DP Mathematics HL and SL, the mathematical exploration has a criterion based on the student's ability to reflect; this examines how well they are able to review, analyse and evaluate the exploration itself, and their ability to reflect on their work.

Application of the maths topics to other areas is expected of Swedish students. This is also an aim of the IB DP courses to apply their skills in other areas and appreciate how mathematics contributes to other disciplines. Further, the IB DP assessment objectives for students to use their knowledge in unfamiliar contexts and to investigate unfamiliar situations may also assess similar skills. Within the IB DP Mathematics HL and SL, investigation of abstract and real-world situations are also required and could have scope to include other disciplines.

Overall, the Swedish courses knowledge requirements imply that Grade A students will be able to demonstrate their knowledge, understanding and application of mathematics with certainty, through detailed descriptions or well-grounded and balanced assessments. Similarly in the IB DP Mathematics HL, students are assessed on the use of mathematics in the mathematical exploration. To receive the highest mark, students must thoroughly demonstrate their mathematics with a high level of accuracy. Use of challenging mathematics is also expected. At IB DP Mathematics SL, a similar expectation is set, but with a few errors allowed at the top grade. IB DP Mathematical Studies SL includes a similar internal assessment criterion on the mathematical processes and the highest grade is awarded when students complete the mathematical processes with no errors.

In regard to the minimum threshold knowledge required for passing the Swedish mathematics courses examined, the IB DP Mathematics HL and SL programmes compare in many areas including knowledge of key concepts, problem-solving, mathematical reasoning, mathematical models, use of digital tools, and an appreciation of the importance of mathematics in other disciplines and contexts.

As with the IB DP Mathematics HL and SL programmes, the IB DP Mathematical Studies SL programme covers most of the threshold knowledge requirements for passing the Högskoleförberedande examen courses. This is in respect to knowledge of key concepts, problem-solving, mathematical reasoning, mathematical models, use of digital tools, and an appreciation of the importance of mathematics in other disciplines and contexts.

In the shared common areas between the Swedish and IB DP courses, it can be expected that the IB DP assessments would assess the skills required to pass the Swedish courses (i.e. the knowledge requirements at Grade E). Nonetheless, it should be acknowledged that the assessment analyses and findings are limited due to the lack of assessment information or consistent format and structure for the Högskoleförberedande examen course assessment.

# 4. Conclusion

Having conducted a policy- / system-, qualification- and subject-level comparative analysis of the Swedish and IB upper secondary education systems, this study has identified many areas where the IB DP aligns closely with the Swedish Högskoleförberedande examen learning outcomes, content and its underpinning philosophies:

### At an overarching level:

The IB DP aligns very closely to the Swedish principles and general objectives for education (specifically, upper secondary education), in particular that both systems seek to:

- Provide students with a solid preparation for higher education or work.
- Support students' holistic, personal development and provide an education that builds not only knowledge, but social, communication, collaborative working and self-management and reflection skills.
- Provide an education that builds knowledge of human rights and democracy as well as the skills to function effectively within it, both in the classroom (through demonstrating respect for others, integrity, open-mindedness) and beyond (as active, responsible, tolerant and competent citizens).
- Develop learners who take responsibility for their own development and learning, both within their secondary studies and beyond, as enthusiastic lifelong learners.

### At a qualification level:

Both systems acknowledge the:

- Importance of providing different options and/or pathways for students to reflect different aspirations, interests and abilities – the IB DP through its structure allowing students to select subjects at SL or HL and across different groups, and the Högskoleförberedande examen through its different national programmes.
- Importance of developing students' subject knowledge, critical thinking and independent study skills, cultural understanding and appreciation, communication, and reflection.
- Need to employ a range of tested teaching and learning strategies where the student is firmly at the centre and independent thinking and reflection, collaborative activities, and activities linking learning to practical and real-world contexts are strongly encouraged.

- Individuality of the learner; the need to effectively monitor learner progress and understanding through formative assessment; and the importance of providing regular constructive feedback and adopting appropriate differentiation strategies.

### At a subject level – the science courses

Clear similarities can be observed in the aims across the science subjects. Both the Högskoleförberedande examen and IB DP:

- Have similar aims for students to develop key knowledge and understanding of the concepts and theories applicable to the subject.

- Acknowledge the importance of utilising current research to support the development of students' curiosity and creativity.

- Aim to develop key practical and experimental skills, including presentation of analyses and conclusions and demonstration of communication skills.

Differences were also found in the aims, in that:

- The IB DP science courses do not include the Högskoleförberedande examen aims for students to develop a specific scientific perspective or approach or to be able to "distinguish between statements based on scientific and non-scientific foundations";
- Having an understanding of the development of theories and models is more a focus in the Högskoleförberedande examen than the IB DP.

When comparing content of the IB DP and Högskoleförberedande examen science courses, it was found that:

- Overall, IB DP subjects include a wider coverage of topics within the individual courses and this is likely a reflection of differences in the structure and number of total courses studied within each qualifications programme.

- In Biology, many topic areas are shared between the programmes including cell and molecular biology, human physiology, and experimental and practical skills. Some differences were found in the focus or content taught in some of the Högskoleförberedande examen; in particular those regarding human development, micoorganisms, and sexually transmitted diseases.

- In Chemistry, all of the Högskoleförberedande examen topics are included or partially included in the IB DP Chemistry SL course:
  - Similar topic areas are taught in both programmes including chemical kinetics and equilibrium, measurement using mass spectrometry, and biochemistry.
  - Differences were also noted where the Högskoleförberedande examen topics are taught at HL level in the IB DP and overall the Chemistry SL programme covers a larger breadth of topics.

- In Physics, the majority of the Högskoleförberedande examen topics are included within the IB DP, with both teaching similar content related to oscillations, reflection and refraction, motion and force. Differences were found where some of the Högskoleförberedande examen content was taught at HL level. Practical skills including evaluation and analysis of information are also similarly taught.

Comparative analysis of the intended learning outcomes for science courses (stated as goals in the Swedish system) revealed that:

- IB DP and Högskoleförberedande examen courses share similar intended learning outcomes for students to have knowledge and understanding of the concepts and theories and the ability to apply their knowledge and skills in a practical setting, conducting experiments, and analysing their findings.

- The Högskoleförberedande examen also expects students to have knowledge related to the importance of science for the individual and society. This is partially reflected within the IB DP but is a larger focus in the IB DP.

Reviewing and comparing assessment and cognitive demand was made more challenging by the fact that there is no centrally prescribed, formal assessment in the Swedish Högskoleförberedande examen for the subjects reviewed in this study. Comparative analysis of the IB DP assessment objectives, assessment criteria and tasks drawn from past exam papers against the prescribed knowledge requirements for Grades A, C and E in the Swedish system found that:

- There are many similarities in the expectations of what students should be assessed on/be able to demonstrate in their assessment. For example, both require that students have knowledge and understanding of key concepts within the subject and be able to apply these with certainty.

- The Högskoleförberedande examen sciences expects students to conduct detailed evaluations that take into account many perspectives; this is similarly assessed in the IB DP external and internal assessments for the science courses.

- Practical skills are assessed within both the Swedish and IB DP science courses, as demonstrated within the IB DP internal assessment and the Group 4 project.

- Both qualifications similarly expect science students to be able to formulate hypotheses, conduct experiments, interpret and justify results and conclusions.

- Higher order thinking skills are similarly expected in the science courses for both programmes; both require students to propose new ideas, changes, or issues for discussion. These skills are assessed in both the external and internal IB DP assessments.

### At a subject level – the mathematics courses

Similarities can also be observed between the aims of the mathematics courses examined in the IB DP and the Högskoleförberedande examen, in particular both:

- Focus on students developing knowledge and understanding in mathematics and the ability to apply their skills in many situations and contexts.

- Aim to challenge students and build their confidence in using mathematics.

When comparing the intended learning outcomes for the Högskoleförberedande examen Mathematics 3c, Mathematics 4 and 5 courses with the IB DP Mathematics HL and SL, and Mathematical Studies SL, the mathematics courses hold similar expectations for students to:

- Use mathematical concepts, formulate and solve problems with and without tools (i.e. calculators).

- Apply mathematics to the real-world and understand its importance in other contexts, and to communicate mathematically.

One difference found in the intended learning outcomes is that although fully included in the IB DP Mathematics HL and SL, the IB DP Mathematical Studies SL course places less focus on students' ability to design a mathematical model, an intended learning outcome in the Swedish course.

Comparative analysis of the content of the IB DP and Högskoleförberedande examen mathematics courses found that:

- Overall, both teach similar content regarding problem solving across all of the mathematics courses, including use of tools such as calculators, application of mathematics in other subjects, and problems related to cultural history of mathematics.

- The IB DP Mathematics HL includes full coverage of content at Mathematics 3c, 4, and 5, with both covering the following:
  - In Mathematics 3c - geometry, functions (including derivatives), and integrals
  - In Mathematics 4 - complex numbers and their application, de Moivre's formula, polynomial equations, trigonometry, functions, and differential equations
  - In Mathematics 5 - differential equations and topics related to discrete mathematics (i.e. congruence, permutations, and recursion).

- The IB DP Mathematics SL course includes many of the same topics as those from HL highlighted above and similar coverage of Mathematics 3c (with the exception of higher order polynomials). Only a few topics are shared with Mathematics 4 and 5.

- The IB DP Mathematical Studies SL compares to a lesser extent with the Högskoleförberedande examen mathematics courses examined in this study. Some

topics are shared with the Mathematics 3c including use of cosine and sine, continuous and discrete limits, tangent, and derivatives of a function. With the exception of the content related to problem solving, few topics are shared with Mathematics 4 and 5.

The review and comparison of assessment and cognitive demand in the IB DP and Swedish Högskoleförberedande examen for the subjects reviewed in this study, was limited due to the absence of centrally prescribed, formal assessment in the Swedish system. Therefore, the analysis focussed on the Swedish knowledge requirements for Grades A, C, and E and how these compared with the IB DP assessment objectives, assessment criteria and tasks drawn from specimen examination papers. In summary, this identified that:

- Both the IB DP and Swedish courses have similar expectations of what students should be able to demonstrate, including: knowledge of key concepts, problem-solving, mathematical reasoning, mathematical models and use of digital tools.

- Similar requirements are set for a Grade A in the Swedish courses and a high mark in the IB DP internal assessments; this includes expectations for students to demonstrate a high level of accuracy in their mathematics and completion of mathematical processes with no errors.

- Overall, the IB DP Mathematics HL, Mathematics SL and Mathematical Studies SL courses similarly assess the skills required to pass the Swedish course, within the shared common areas of the courses.

## 4.1 Limitations of the study

The absence of centrally prescribed, formal assessment (whether internal or external) in Sweden for the subjects and courses examined made it difficult to draw full conclusions on the relative cognitive demand of assessment in the IB DP and Högskoleförberedande examen. Broad conclusions were therefore drawn from analysis of the materials available for the Högskoleförberedande examen including the subject level knowledge requirements.

It should also be noted that this study is purely based on a documentation review and analysis and did not examine actual delivery or performance of the Högskoleförberedande examen or the IB DP. For example, the analysis of pedagogical approaches compared the guidelines for teachers to work towards within the reformed Swedish education system whilst audits by the Swedish Schools Inspectorate show that there is still some way to go in terms of developing students' participation and influence in the classroom.

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# Appendix 1: Information on UK NARIC

UK NARIC is the designated national agency in the United Kingdom for the recognition of international qualifications and professional skills. Since 1997, it has performed this official function on behalf of the UK Government.

UK NARIC provides informed advice and guidance on vocational, academic and professional qualifications from over 190 countries worldwide. The information provided enables international and UK organisations, institutions and government agencies to develop informed opinions when considering qualifications or training systems from overseas.

With the expertise and experience developed through running the National Agency, together with a number of other programmes on behalf of the UK Government and European Union, UK NARIC has been uniquely well placed to manage and support delivery of an extensive global research portfolio for:

- Ministries of Education and other government agencies
- Universities and other higher education institutions
- Secondary exam boards and awarding bodies
- Professional bodies.

Specific areas of expertise include:

- International education systems and qualifications
- Comparative studies on curriculum and assessment
- Qualification benchmarking
- Grade comparisons
- Best practice in recognition
- Qualification framework development and/or referencing;
- Supporting the development and implementation of mutual recognition agreements.

# Appendix 2: IB DP Assessment Methods

**Table 30: IB DP Biology assessment format**

| | IB DP Biology SL |
|---|---|
| Number and type of assessments each examination series | Three written external examinations<br>One internal assessment |
| Duration | Paper One: 45 minutes<br>Paper Two: 1 hour 15 minutes<br>Paper Three: 1 hour<br>Internal assessment: 10 hours |
| Type(s) of question | Paper One: multiple choice questions<br>Paper Two: data-based questions, short answers and extended response questions (students answer one out of two extended response questions)<br>Paper Three:<br>• Section A: short answer questions based on experimental skills and techniques, analysis and evaluation, using unseen data<br>• Section B: short answer and extended response questions from one optional topic content<br>Internal assessment: one scientific investigation and 6 to12 page write-up |
| Total marks available | Paper One: 30 marks<br>Paper Two: 50 marks<br>Paper Three: 35 marks<br>Internal assessment: 24 marks |

**Table 31: IB DP Chemistry assessment format**

| | IB DP Chemistry SL |
|---|---|
| Number and type of assessments each examination series | Three written external examinations<br>One internal assessment |
| Duration | External assessment<br>Paper One: 1 hour<br>Paper Two: 2 hours 15 minutes<br>Paper Three: 1 hour 15 minutes<br>Internal assessment: 10 hours |

| | IB DP Chemistry SL |
|---|---|
| Type(s) of question | Paper One: multiple choice questions<br>Paper Two: data-based questions, short answers and extended response questions (students can answer two out of three extended response questions)<br>Paper Three:<br>Section A: short answer questions based on experimental skills and techniques, analysis and evaluation, using unseen data<br>Section B: short answer and extended response questions from one optional topic content<br>Internal assessment: one scientific investigation about 6 to 12 pages |
| Total marks available | Paper One: 40 marks<br>Paper Two: 72 marks<br>Paper Three: 45 marks<br>Internal assessment: 24 marks |

**Table 32: IB DP Physics assessment format**

| | IB DP Physics SL |
|---|---|
| Number and type of assessments each examination series | Three written external examinations<br>One internal assessment |
| Duration | Paper One: 45 minutes<br>Paper Two: 1 hour 15 mins<br>Paper Three: 1 hour<br>Internal Assessment: 10 hours |
| Type(s) of question | Paper One: Multiple choice questions<br>Paper Two: Short answer questions and extended questions<br>Paper Three: Multi-part and extended questions<br>Internal assessment: one scientific investigation about 6 to 12 pages |
| Total marks available | Paper One: 30 marks<br>Paper Two: 50 marks<br>Paper Three: 35 marks<br>Individual investigation: 24 marks |

**Table 33: Högskoleförberedande examen and IB DP Mathematics assessment format**

| | IB DP Mathematics |
|---|---|
| Number and type of assessments each examination series | Mathematical Studies SL: two examination papers and one project<br>Mathematics SL: two examination papers and one mathematical exploration (written investigation of an area of mathematics)<br>Mathematics HL: three examination papers (Paper 1 and 2 on core topics and Paper 3 on one optional topic[19]) and one mathematical exploration (written investigation of an area of mathematics) |
| Duration | Mathematical Studies SL:<br>• Paper 1: 1.5 hours<br>• Paper 2: 1.5 hours<br>• Project: approx. 25 teaching hours<br>Mathematics SL:<br>• Paper 1: 1.5 hours<br>• Paper 2: 1.5 hours<br>• Mathematical exploration: 10 teaching hours<br>Mathematics HL:<br>• Paper 1: 2 hours<br>• Paper 2: 2 hours<br>• Paper 3: 1 hour<br>• Mathematical exploration:10 teaching hours |
| Type(s) of question | Mathematical Studies SL: Short answer[20] and multi-part structured<br><br>Mathematics SL: Short answer[21], multi-part structured, extended problem, and combination of multi-part structured and extended problem<br><br>Mathematics HL: Short answer[22], multi-part structured, extended problem, and combination of multi-part structured and extended problem |
| Total marks available | Mathematical Studies SL:<br>• Paper 1: 90 marks<br>• Paper 2: 90 marks<br>• Project: 20 marks<br>Mathematics SL:<br>• Paper 1: 90 marks<br>• Paper 2: 90 marks |

[19] Examination in either topics of discrete mathematics; calculus; sets, relations and groups; and statistics and probability.
[20] The IB Mathematical Studies SL papers include a number of short answer sub-questions as part of a larger multi-part question.
[21] The IB Mathematics SL papers include a number of short answer sub-questions as part of a larger multi-part question.
[22] The IB Mathematics HL papers include a number of short answer sub-questions as part of a larger multi-part question.

| | IB DP Mathematics |
|---|---|
| | • Mathematical exploration: 20 marks<br>Mathematics HL:<br>• Paper 1: 100 marks<br>• Paper 2: 100 marks<br>• Paper 3: 50 marks<br>• Mathematical exploration: 20 marks |

# Appendix 3: Högskoleförberedande examen Knowledge Requirements for Physics 2 and Chemistry 2

The following tables demonstrate the knowledge requirements for Physics 2 and Chemistry 2 in the Högskoleförberedande examen. These are largely the same as the knowledge requirements for Biology 2, with minor word changes included that reflect the subject. These subject related word changes have been underlined in the tables below.

**Table 34: Högskoleförberedande examen knowledge requirements for Physics 2**

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| Students give an account **in basic terms** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with some certainty** to look for answers to issues, and also to describe and **exemplify** the phenomena and relationships of physics. Based on **some** example, students give an account **in basic terms** of how the models and theories of physics have been developed. | Students give an account **in detail and in a balanced way** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with certainty** to look for answers to issues, and to **describe and generalise** the phenomena and relationships of physics. Based **on some examples** students give an account **in detail and in a balanced way** of how the theories and models of physics are developed. |
| Students also evaluate the validity of the models and theories and their limitations in **simple** assessments. | Students evaluate also the validity and limitations of models and theories in **balanced** assessments. |
| Students identify, analyse and solve **simple** problems in **familiar situations** with **satisfactory** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with some certainty** their own issues. Students plan and carry out **in consultation** with the supervisor experiments and observations in a satisfactory way. In addition, students handle materials and equipment safely. Furthermore, students interpret their results, evaluate their methods in **simple** assessments and give the reasons for their conclusions with simple reasoning. | Students identify, analyse and solve **complex** problems in **familiar and new situations** with **good** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with certainty complex** issues. Students plan and carry out **after consultation** with the supervisor experiments and observations in a satisfactory way. In addition, students handle materials and equipment safely. Furthermore, students interpret their results, assess their methods in **balanced** assessments and give reasons for their conclusions with **well grounded and balanced** reasoning. **Where necessary, students also propose changes.** |
| Students discuss in **basic terms** issues concerning the importance of physics for the individual and society. In their discussions, students put forward **simple** arguments and give an account **in basic terms** of the consequences of **some** possible viewpoints. | Students **discuss in detail and in a balanced way complex** issues concerning the importance of physics for the individual and society. In their discussions, students put forward **well grounded and balanced** arguments and give an account **in detail and in a balanced way** of the consequences of **several** possible viewpoints. **Students also propose new issues for discussion.** |
| Students use **with some certainty** the language of science and adapt **to some extent** their communication to purpose and context. In addition, students use different types of sources and make **simple** assessments of the credibility and relevance of their sources and information. | Students use **with some certainty** the language of science and adapt **to a great extent** their communication to purpose and context. Students use different types of sources and make **well grounded and balanced** assessments of the credibility and relevance of their sources and information. |
| In consultation with the supervisor, students assess **with some certainty** their own ability and the requirements of the situation. | In consultation with the supervisor, students assess **with certainty** their own ability and the requirements of the situation. |

**Table 35: Högskoleförberedande examen knowledge requirements for Chemistry 2**

| Grade E Knowledge Requirements | Grade A Knowledge Requirements |
|---|---|
| Students give an account **in basic terms** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with some certainty** to look for answers to issues, and also to describe and **exemplify** chemical processes and phenomena. Based on **some** example, students give an account **in basic terms** of how the models and theories of chemistry are developed. | Students give an account **in detail and in a balanced way** of the meaning of concepts, models, theories and working methods from each of the course's different areas. Students use these **with certainty** to look for answers to issues, and to **describe and generalise about** chemical processes and phenomena. Based **on some examples** students give an account **in detail and a balanced way** of how the theories and models of chemistry are developed. |
| Students also evaluate the validity of the models and theories and their limitations in **simple** assessments. | Students also assess the validity and limitations of models and theories in **balanced** assessments. |
| Students analyse and look for answers to **simple** questions in **familiar situations** with **satisfactory** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with some certainty** their own **simple** issues. Students plan and carry out **in consultation** with the supervisor experiments and observations in a satisfactory way. In addition, students handle chemicals and equipment safely. Furthermore, students interpret their results, evaluate their methods in **simple** assessments and give the reasons for their conclusions with simple reasoning. | Students analyse and look for answers to **complex** questions in **familiar and new situations** with **good** results. This applies to both theoretical and practical work. In their work, students formulate relevant hypotheses and formulate **with certainty complex** issues. Students plan and carry out **after consultation** with the supervisor experiments and observations in a satisfactory way. In addition, students handle chemicals and equipment safely. Furthermore, students interpret their results, assess their methods in **balanced** assessments and give reasons for their conclusions with **well grounded and balanced** reasoning. **Where necessary, students also propose changes.** |
| Students discuss in **basic terms** issues concerning the importance of biology for the individual and society. In their discussions, students put forward **simple** arguments and give an account **in basic terms** of the consequences of **some** possible viewpoints. | Students **discuss in detail and in a balanced way complex** issues concerning the importance of biology for the individual and society. In their discussions, students put forward **well grounded and balanced** arguments and give an account **in detail and in a balanced way** of the consequences of **several** possible viewpoints. **Students also propose new issues for discussion.** |
| Students use **with some certainty** the language of science and adapt **to some extent** their communication to purpose and context. In addition, students use different types of sources and make **simple** assessments of the credibility and relevance of their sources and information. | Students use **with some certainty** the language of science and adapt **to a great extent** their communication to purpose and context. Students use different types of sources and make **well grounded and balanced** assessments of the credibility and relevance of their sources and information. |
| In consultation with the supervisor, students assess **with some certainty** their own ability and the requirements of the situation. | In consultation with the supervisor, students assess **with certainty** their own ability and the requirements of the situation. |