

Internal Assessment in IB Physics: Teacher support

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INTRODUCTION

Theory and experiment

IB students are active learners. Both in the real world and at the high-school level, theory and experiment play complementary roles in science. For this reason the IB expects group 4 science teachers to integrate scientific theory with practical work. Hands-on activities allow students to achieve the group 4 aims and to fulfil the group 4 assessment objectives. Moreover, practical work allows students the opportunity to design investigations, and collect, process, analyse and evaluate data. Practical work also allows students to develop manipulative and technological skills, and collaborate with fellow students. Practical work reinforces the understanding of theoretical concepts as well as demonstrating the empirical side of science.

The IB encourages a wide range of practical activities, from traditional laboratory investigations (both syllabus-based and non-syllabus-based) to computer simulations, online databases and mathematical modelling. Technology plays an essential role in laboratory work, and students should gain experience and develop ICT skills. The expectation (as noted on the 4/PSOW form) is that students experience the following at least once in the two-year course: data logging, graph-plotting software, spreadsheet analysis, database information, and computer modelling or simulations.

The syllabus contains a number of prescribed experiments. These are listed on the left-hand side of the syllabus format, under the Applications and skills section. The required experiments are generic: for example, investigating one of the gas laws experimentally, or experimentally determining the value of free-fall gravity, or investigating the activity of catalase enzymes. The details of how to implement these experiments are left to the teacher; however, the prescribed experiment topics are subject to examination. On the right-hand side of the syllabus format, under the Aims section, there are some suggested experiments relating to the given topic. These are not required but are based on teachers' best practices. The inclusion of experimental work in both the syllabus content and on exams clearly indicates its importance in science education.

Class time

Students should spend 25% of class time actively involved with investigative work. At Standard Level students have 40 hours of hands-on activities over two years and at Higher Level they have 60 hours. This time consists of 10 hours for the group 4 project and 10 hours for the internal assessment investigation, with the remaining hours (20 at Standard Level, 40 hours at Higher Level) being spent on other lab work which is not assessed but is included on the 4/PSOW form.

Grades

At the end of the two-year course students sit three written exam papers. The achievement from these papers is combined with an individual student investigation, called an 'internal assessment' (IA). The teacher marks the IA investigation but the IB moderates a selection of student IA work externally. The IA is worth 20% of the student's total grade.

Internal assessment profile

The IA is a scientific investigation which is unique for each student. It should have a purposeful research question and a scientific rationale for the study. In an educational sense, the IA models a real scientific study in form and content. The following is an overview of the internal assessment.

Research question – The student is to define a unique research question.

Guidance – The teacher is to guide the student from beginning to end.

Time allocation – Ten hours of class time but student can do additional work outside of class.

Context – Students are to set their investigation in an appropriate scientific context.

Research – Students are expected to do research on their topic.

Content – The student does not have to demonstrate knowledge or skills that go beyond the level of their course, although students can do an investigation that is not syllabus-based.

Report length – 6 to 12 pages (excessive length will be penalised). The maximum length includes footnotes or references as well as data tables, graphs and charts, pictures and, of course, text.

Personal involvement – Students are expected to 'own' their investigation, to demonstrate some insight, initiative or personal interest in their investigation.

Self-management – Students are responsible for their work, including meeting deadlines.

Technology skills – Students need ICT skills, including word-processing, spreadsheets, graphing software, and internet searches. They must also know how to reference resources.

Presentation – The final report is to be electronic, with word-processed text, mathematical equations and electronically drawn graphs. The entire report should be a single document, including references.

Investigation types

The IA criteria allow for and indeed encourage a wide range of investigation types.

Hands-on investigations – This includes many traditional experiments. Investigations are not restricted to syllabus content, and the concepts and skills required need only be in line with the level of the course the student is taking.

Modelling and spreadsheet investigations – Here the student may process primary or secondary data and analyse it with a computer model. Spreadsheets and graphing software can be used in all investigation types. In some cases, real data can be compared to ideal or theoretical data by using a spreadsheet.

Database investigations – Here the student would access online databases for scientific information. They would design a method to answer their research question using the database, and perhaps graph or model their results. Teachers with large classes may encourage students to take this approach.

Computer-simulation investigations – Investigations may involve computer simulations. Here, students can obtain information or data that will be processed to discover something that goes beyond the simulation's routine. Students can also combine a hands-on investigation with a computer model and compare the results. Students may also combine real data with a mathematical model.

Hybrid investigations – It is understood that students might perform any combination of the above investigation types. The types are not exclusive categories but rather illustrate the wide range of acceptable investigation types.

PLANNING

It is essential to the student's success that the IA investigation be properly planned. This is the responsibility of the teacher and requires the coordination of the biology, chemistry and physics teachers.

Background experience

Because of the academic demands on the student it is highly recommend that the IA take place sometime in the second year of the two-year course. Students should have experienced a wide range of topics and investigatory techniques before starting the IA. Exceptions to this would be in schools that teach the IB course in one year or in schools where students have had substantial pre-IB science experiences.

Scheduling coordination

Because biology, chemistry and physics students follow identical IA criteria it is important that the group 4 teachers coordinate the scheduling of the IA work. This is especially true because some students may be taking two sciences. Also, there is the consideration of the ten-hour group 4 project, other IB projects like the mathematics IA, the Theory of Knowledge requirements, and extended essay work.

Resources

Issues that need to be addressed here include classroom and laboratory space, the availability of equipment and materials, and appropriate teacher or laboratory technician support, as well as student access to computers and the internet. Limited resources or large class sizes are important factors in the timing of the IA work.

Timing

Ten hours of class time are to be devoted to the IA. This is the time permitted on the 4/PSOW form. Students and teachers may use additional time out of class. The ten hours include:

- introducing the ideas and expectations of the IA
- discussing the IA criteria
- explaining the scheduling and the internal deadlines
- explaining the wide range of possible investigation types
- an overview of available science resources and materials
- outlining a number of plausible investigation topics
- providing students with several exemplar IA reports
- individual student consultation to help students define a research question
- teacher approval of a student's IA proposal
- time to learn the use of equipment or use of resources like simulation or a database
- the experimental time during which students conduct their investigation
- feedback and guidance from the teacher as the student works on their experiment
- writing a first draft and more teacher guidance (constructive but general comments only)
- writing the final draft and submitting the IA report to the teacher.

The ten hours of class time should be arranged in a manner that works best for the individual school. This is up to the teachers. There are two possible approaches:

Consecutive timing – Here the IA starts, follows through and ends with a continuous ten hours of class time. This may take two or three weeks, depending on the school's timetable. A consecutive measure of time may not be to the benefit of the teacher or

student, however. Often it takes time to focus, research and develop a workable research question.

Non-consecutive timing – There are advantages to this approach. For example, in one lesson in the first week, the IA expectations can be explained and the stage can be set for students to think about a research topic. In one lesson during the next week students might consult with the teacher about their ideas. Then the student might do some academic research. In week three you might devote all the class time to experimental work. Then in the next week you might take a lesson to read a draft of the student's report and give feedback, and in the final week collect the completed IA reports. This approach is advantageous to the student, giving them ample time to process and perfect their work, and gives the teacher more time to provide guidance to the student. There are numerous variations on the non-consecutive time schedule.

GUIDANCE

Research question

Although the teacher guides the student throughout the IA work, it remains the student's responsibility to formulate a research question. The student is expected to show interest and initiative in defining and implementing their investigation.

Perhaps a student is interested in a certain topic. Consultation with the teacher can help the student focus and define a meaningful investigation. Although the teacher should not assign experiments or research topics, students cannot be left on their own to come up with a suitable investigation. The student must be involved in this discussion. First and foremost, the research question must be appropriate for the criteria. The research question must be scientifically interesting, worthy of study, but also focused enough to be achievable within the time limits. Too simple an investigation or too complex an investigation would harm the student's chances of success. Although not an IB requirement, it is recommended that teachers approve, reject or help the student modify their research question before work starts.

Here is an example where the student has studied alternating current in a transformer (Syllabus topic 11.2). They learned that energy is always lost between the primary and secondary coils of the transformer. The student tells the teacher they want to investigate this energy loss in detail, and perhaps determine the efficiency of a transformer. Talking with the teacher reveals a large number of variables, many of which would be difficult to study in the high-school laboratory. The teacher then asks what is constant in all the transformers, and the student realises that the frequency of the voltage is always the same. The student then has an exciting insight: using a signal generator and, keeping all the other transformer variables constant, the student can easily vary the frequency. By comparing the input and output voltages on a one-to-one ratio

transformer, the student can determine the relationship between frequency and efficiency. This is a well-focused, scientifically interesting and most achievable investigation. Moreover, there is scientific knowledge in this area. The student will research and compare their results with the accepted theory.

Responsibilities

The teacher and the student are responsible for the authenticity of the work, for safety issues and for any ethical, social or environmental issues.

Authenticity – Although the student signs an IA form stating that the work is their own, it is also the teacher’s responsibility to make sure the students work is authentic. For further details, see the IB publications *Academic Honesty* (2011) and *The Diploma Programme: From Principles into Practice* (2009). To assure authenticity the teacher should be present when the student carries out an experiment or gathers data. The teacher can check for authenticity when the student first makes a proposal. The teacher can check the first draft of the written work for authenticity, and the teacher can check the references cited. The teacher can also consider the student’s writing style (is it consistent with other known work from the student?). Finally, the teacher can check for plagiarism in the student’s first and final drafts by using an internet service such as <http://turnitin.com>.

Safety – Teachers are responsible for following national and local guidelines for safety in the classroom. In addition to this and common sense, the *Course Guide* includes some 40 suggestions for a safe laboratory.

Ethical, social and environmental issues – The group 4 Aim 8 and Assessment objective 4 are addressed here, as well as part of the Exploration criterion that deals with safety, environmental and ethical considerations of the student’s IA work. Where appropriate, teachers must explain to students the *IB Animal Experimentation Policy* (2009).

THE STUDENT REPORT

Style and form

There is no prescribed style or format for an IA report. The assessment criteria suggest a logical and justified approach, however. This means that an articulate and easy-to-follow structure is expected. Moreover, the IA is meant to reflect a genuine scientific journal article. For this reason, it might be useful for students to look at a number of scientific journal articles, such as the British publication *Physics Education* (<http://iopscience.iop.org/0031-9120>) or the American publication *The Physics Teacher* (<http://tpt.aapt.org>). These journals and others often have



articles that are appropriate for high-school work. Many of these articles can provide good ideas for an IA investigation.

Because the student's lab report is written after the experiment is done, it is reasonable to expect it to be written in the past tense. It is advisable to avoid pronouns but in general there is no prescribed narrative mode.

References

It is essential for authenticity and academic honesty that students reference all resources, including images and pictures. The method of reference should be standardised and consistent, but there is no one method of referencing sources prescribed by the IB.

Length

The IB recommends that the total length of the IA report, including footnotes or references, charts, graphs, and pictures, be between 6 and 12 pages. Excessive length, beyond 12 pages, will be penalised under the Communication criterion.

ASSESSMENT CRITERIA

There are five assessment criteria. Each begins with a general statement. The marking grid then provides a number of descriptors or statements about the student's achievement level for the criterion. These indicators explain how you are to assess the given criterion. You need to refer to the *Course Guide* for the detailed statements and complete listings of achievement level descriptors.

Personal engagement

Students are expected to make their investigation their own unique investigation. This can be demonstrated in various ways, including the expression of personal interest in the topic or by showing initiative, insight or innovation in the implementation of their investigation. Although the teacher may guide the student into productive and safe areas of study, the student is expected to define their own research question. Repeating a standard experimental method for a standard experiment would not address the Personal engagement criterion. The Personal engagement criterion can earn from zero to two marks and has 8% weight on the overall IA grade.

Exploration

Students are expected to state a scientifically relevant and focused research question. Students are to do research and set their research question in a scientific context. Students should use appropriate terminology and appropriate scientific techniques to answer their research question. Students must also be aware of factors that might influence the relevance, reliability and the quality of their data. If environmental and safety issues are relevant then students must

demonstrate a full awareness of these issues. The Exploration criterion can earn from zero to six marks and has 25% weight on the overall IA grade.

Analysis

Students are expected to make an appropriate and justified analysis of their data in a way that addresses the research question and can be used to support a valid conclusion. This analysis includes the selection, processing and interpretation of data. Errors and uncertainties, where relevant, are to be dealt with in a reasonable and consistent way. The Analysis criterion can earn from zero to six marks and has 25% weight on the overall IA grade.

Evaluation

Students are expected to express a relevant evaluation of the investigation process or methodology and of the data and analysis in terms of the research question. Students should also demonstrate an understanding of the wider context of real-world scientific knowledge in their evaluation. If there is an accepted scientific answer to the research question then this must be compared to the student's results. Extensions of the study or improvements in the methodology can be mentioned in the student's evaluation. The Evaluation criterion can earn from zero to six marks and has 25% weight on the overall IA grade.

Communication

Students are expected to produce a written report that is clear and easy to follow. The report is to demonstrate effective communication and should be focused on the investigation's process and outcome. No superfluous material should be included. The report is to be 6 to 12 pages in length; excessive length will be penalised under this criterion. Appropriate scientific terminology and conventions must be followed, and graphs, tables, images, charts must all be presented in a clear way. The Communication criterion can earn from zero to four marks and has 17% weight on the overall IA grade.

The five IA criteria add up to a maximum of 24 marks. Three written exam papers and the IA determine the student's overall course grade. The IA is one-fifth of the overall grade.

ASSESSING IA

Procedure and process

You will recall that the guidance given to the student during the designing and implementation stages, and the guidance given on the student's first draft, is general guidance. We cannot tell the student what needs to be done. Moreover, teachers cannot grade the draft according to the IA criteria. We only mark the final copy, and after this assessment students are not allowed to make any changes.

Our assessment of IA needs to be at the same level for both Standard and Higher Level students. The criteria are the same so the assessment must be the same even if student's backgrounds differ.

If two or more teachers are working with students registered for the same science subject then it is essential that the teachers agree on assessment standards.

Teachers assess all their students' completed IA reports. When the marks are submitted to the IB online, the IB selects a representative sample and moderates these. The selected lab reports will be submitted electronically, online, so each student's IA report must be a single file, probably an MS Word file (including data, graphs and charts, pictures and references).

To facilitate the IB's moderation process teachers should provide specific evidence of their assessment decisions, criterion by criterion. The student's report can be commented upon, electronically, or a report can be made in a separate file. There is a Candidates IA Cover Sheet, IB form 4/ICSS that needs to be completed with individual IA marks. This is in addition to the 4/PSOW form and the 4/IA Teacher Checklist form.

Markbands

A grid of Marks and Descriptors follows each criterion assessment statement.

Criterion name

Criterion assessment statement

<i>Mark</i>	<i>Descriptor</i>
0	Indicator statement for markband 0
1–2	Indicator statement 1 for markband 1–2
	Indicator statement 2 for markband 1–2
	Indicator statement 3 for markband 1–2
3–4	Indicator statement 1 for markband 3–4
	Indicator statement 2 for markband 3–4
	Indicator statement 3 for markband 3–4

Marks are to be awarded only as integers – no fractions. The marks are presented in markbands. In Personal engagement, for example, each markband represents only one level of achievement. For the Exploration markbands, however, each markband represents two levels of achievement. Markbands are a comprehensive statement of expected performance against which responses are judged. They represent a single criterion divided into level descriptors.



Descriptors

Each markband contains descriptors for the various levels of achievement for a number of qualities used to assess the criterion. For example, for the Analysis criterion, each markband deals with (a) raw data, (b) data processing, (c) the impact of uncertainties, and (d) the interpretation of the processed data. Markband zero states that the report does not reach a standard described by any of the descriptors.

Relevance

It is possible that some descriptor statements will not pertain to a given investigation. For example, a student may have used a computer simulation to develop an interesting model of a certain phenomenon. We would not expect the awareness of safety, environmental or ethical concerns in this investigation, so the last sentence of the Exploration criterion would not be assessed. This issue would be irrelevant when it comes to determining the overall level of achievement for Exploration.

Interpretation

Even if the same descriptors are appropriate for a given markband, it is up to the teacher to interpret whether the achievement is at the upper or lower mark. For example, under Analysis assume that all the descriptors in the 3–4 markband are appropriate. Does the student earn a 3 or a 4? This is up to you; you must make a decision on how well the descriptors fit – totally or just barely. This is not a subjective judgement but rather an educated and reasoned judgement. But what if descriptors from different markbands are appropriate?

Best-fit method

Because there are a number of issues addressed in each markband and because there are a number of different markband levels, the overall assessment of a given criterion may include indicator statements from different markbands. Indeed, this will happen. We have already mentioned relevance. The indicator may or may not be relevant for a given investigation. A mathematical model based on theory alone would not have errors and uncertainties. As a result, the IB tells us to determine the achievement level by the method of best fit. This is the same idea as the best-fit method used when drawing a line on a scatter graph. There may well be an outlier, a datum point that we should ignore. We adjust the best-fit linear line to have an overall balance of data points above and below the line. With IA, we also balance the overall quality of a given report against the given criterion.

The aim of the best-fit method is to find the indicator statements that convey **most accurately** the level attained by the student's work. The most accurate is not necessarily the most precise. There are a number of possible combinations of indicator statements. Here are just a few.

Mark	Indicator statements			
	Report A	Report B	Report C	Report D
0	-	-	X	X
	-	-	-	X
1–2	-	X	-	-
	-	X	X	-
3–4	X	-	-	-
	X	-	-	-
	X	X	X	X
	X	X	-	-
5–6	-	-	-	-
	-	-	-	-
	-	-	-	-
	-	-	X	X

Consider the evaluation for four different lab reports (see the chart above). An 'X' indicates that a given indicator statement applies to the work. In Report A above we know that the student earns either 3 or 4 marks. You must decide on the level here. Ask yourself: to what extent does the student satisfy each indicator? This is never a black or white matter. Perhaps Report A earns a 3.

In Report B we might decide on 2 or 3 marks; again you have to decide just how well each indicator statement is satisfied. Perhaps missing the first one has little effect on the overall investigation, so we give Report B a mark of 3.

In Report C the best fit is harder to determine as we have a significant range. A similar situation occurs with Report D. Many times as teachers we can sense the overall quality of a lab report (without detailed assessment statements). A similar approach, but paying attention to the indicators, applies here. Marking a Report by IA criteria is not a simple checklist.

Teacher support

You are reminded that there are ten student lab reports, with moderator comments and assessment explanations, on the IB's Online Curriculum Centre (OCC) website. The Teacher Support Material (TSM) also includes advice on the application and interpretation of the criteria and on other relevant issues.