Higher level and standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-3	4-6	7-10	11-13	14-16	17-19	20-24

The range and suitability of the work submitted

The range of student work covered a spectrum of investigations, ranging from basic to most impressive. At one extreme there was an IA measuring the effect voltage has on current for a fixed resistor, the impact speed of a free-fall ball related to the drop height, and another on determining a spring constant. These investigations were too basic and too obvious to earn high marks under Exploration. Sometimes teachers allowed students to follow one of the prescribed investigations. These are generic investigation requirements, meaning that the details of method and technique are up to the teacher or student. As such, a required investigation could be a starting point for an IA, although the teacher needs to be careful doing this. For example, the student knows about the length of a simple pendulum and the period of oscillation but then decides to investigate large displacement angles where the basic equation no longer holds. This would be a justified extension of a generic investigation. On the more impressive end of the spectrum of investigation types there was a database investigation establishing the circumstellar zones for certain stars. Bifilar pendulums were popular, as was the variation of refractive index as a function of a liquid density. Computer simulations were used to determine the charge of an electron, to measure the universal gravitational constant, and other physics quantities that would normally be difficult to determine in the classroom. There were some original investigations too, including a study of Tsunami effects, the permeability of free space, the angle of liquid in a container under acceleration, and variations on the Doppler effect.

The majority of student work involved hands-on investigations, with primary data collection in the school laboratory. This approach allowed addressing all the assessment criteria. Mechanics was the most popular topic, but electricity and magnetism, waves, and astrophysics were common too. A surprisingly low number of investigations were mathematical models, computer simulations and database investigations.

Candidate performance against each criterion

Personal Engagement Strengths:

When a student report demonstrates independent thinking, initiative or creativity, and when there is personal significant, interest and curiosity in the chosen research question, and when there is personal input in the design or implementation or presentation of the investigation, then the student has addressed the personal engagement criterion. PE is assessed holistically.

It was encouraging to see that some students had modified a traditional investigation or designed their own investigation, thus demonstrating independent and creative thinking. Performing an investigation with a standard method and standard analysis but in a thoughtful and competent way often earned one mark for PE. Only the most insightful and thoughtful investigations demonstrated the qualities expressed by the PE descriptors.

Personal Engagement Weaknesses:

Students would often over-emphasized ‘personal significance’ by writing what seemed to be artificial comments about their interests. Teachers need to encourage students to demonstrate their curiosity and insight in the investigation itself, in the nature of the research question, in the details of methodology and analysis, and in other contributions made by the student to their individual investigation. Teachers often over marked PE thinking that an interest in the general topic was enough to earn full marks. Because PE is assessed in a holistic way, students should not add a sub-title section “Personal Engagement.”

Exploration Strengths:

Many students produced interesting and challenging investigations. These always included a single and well-defined independent variable and a quantifiable dependent variable. Appropriate investigations often made use of known scientific concepts and equations. As a result, analysis was focused in a relevant way. Issues of safety, ethical and environmental concerns were mentioned when appropriate. Moderators were impressed by the degree of student engagement and imagination.

Exploration Weaknesses:

Some students had vague research questions, never defining the key issues. Some investigations had multiple independent variables. This usually harmed the quality of the investigation as it took the student’s attention away from a more focused study. Some students made up a scientific context, following common sense when there was relevant theory but never realized by the student.

Some investigations were too simple and the research question too obvious, like finding the spring constant for a rubber band or investigating the impact speed from free fall at different heights. An inappropriate question was “Which is more efficient: boiling water with an electric kettle or boiling water in a pot on the stove?” Or, “What type of ball bounces the highest?” More appropriate research questions look for functions or relationships between two variables, or to determine an important constant in nature. Occasionally students thought that a history of physics provided background when in fact all it did was distract the focus of the investigation.

Analysis Strengths:

Analysis includes the traditional scientific skills that assess data collection, data processing, appreciation of errors and uncertainties, the scope and limit of the data, graphing and methodological issues. These are traditional scientific skills, and the majority of students demonstrated a sound mastery of analysis. The majority of students demonstrated the ability to obtain and record data, including raw uncertainties. Data tables were clear and consistent with scientific notation. Processing was often detailed, with sample calculations. Graphs were nicely presented often with error bars. The majority of student graphs were computer generated. In most cases theory and hypothesis directed the appropriate graph representation. Often students used more advanced methods of error analysis, and this was successful.

Analysis Weaknesses:

Occasionally raw data was incorrectly recorded, omitting uncertainties. Column headings should include the quantity, units and uncertainty. Occasionally incorrect units, such as feet and minutes, were used. Claiming a metre rule could measure distances to 0.01 mm is unlikely to be true. Some graphs lacked appropriate detail, and some graphs were too small to appreciate. This would affect the Communications assessment. In some cases, data scatter suggested a curve and yet the student forced a linear fit. The linear fit was then used to establish a conclusion. One student thought they established a linear relationship between the length of a pendulum and the period. Teachers should encourage students to consider how the relevant theory applies and how the graph should look. Considering what the *x* and *y* intercepts mean in terms of the physical properties under study. Students need to be careful when claiming results prove something. There should always be a range and limit to the meaning of a given investigation.

Evaluation Strengths:

The evaluation criterion remains one of the hardest criterions to address for many students. Focus is the key here and students who justified a conclusion for their investigation based on the original research question did well. The propagation of uncertainties was a key part for successful students. When there is a known scientific context or accepted value, then students who compared their result with the accepted value did better. The more successful student reports showed an appreciation for any assumptions in their methodology.

Evaluation Weaknesses:

Students need to be careful with statements about proving a hypothesis. An appreciation of the scope and limit, the methodology and any theoretical assumptions should be addressed when evaluating a conclusion. Often the terms proportional and linear were confused. Often students would construct a meaningless polynomial equation to fit their data and then assert a conclusion described by the equation, without giving any physical meaning to the results. Too often students would force data to fit a linear graph and then state this as a conclusion with the linear line as the justification. In an Evaluation students need to appreciate the physical meaning of the quantities under investigation, and so they need to interpret the data correctly. Many times students failed to appreciate the physical quantities under study and so they failed to appreciate what they have established. There is more to a graph than a simple equation.

Communications Strengths:

Communications, like Personal Engagement, is assessed holistically. This means that the overall clarity, flow and focus of the report is assessed. The best reports made it clear in the first paragraph what the specific investigation was about, how it was conducted and what results were found. The best reports stayed focused on the research question and related physics content. The best reports had specific titles, like “How the temperature of a rubber band affects its spring constant” and not generic titles like “Investigating Machines.” The majority of reports used correct and relevant scientific notation, equations and units. The majority of reports were within the 6 to 12-page expectation. Reasonable margins, spacing, appropriate scales of graphs and data tables, all help the communications criterion. Most students consistently and appropriately provide references to their work (in a variety of consistent and acceptable ways). Academic research is expected. Research questions and hypothesis need to be supported by relevant scientific information, relevant to the investigation (and not historical background or how much a student enjoys physics class).

Communications Weaknesses:

A number of students omitted any sort of investigation title. Some students wrote “IA Investigation” or vague titles like “Investigating Light.” A cover sheet is not necessary. A table of contents may give the reader an overview but is not necessary either. Significant sections relating to personal interest and the history of science often contributed little to the achievement of the student. Investigations need to refer to the research question early. Step by step instructions were too detailed in some cases and unnecessary. Students do not need to include a photographs of a metre rule or a stopwatch. This can lead to wasted space. Often reports with excessive content (e.g. 16 or 18 pages) inhibited the clarity of the report. Occasionally students would copy pictures from the Internet or a textbook and not give the reference. In some cases, this was obvious, but referencing is required for all material that is not original. Communications does not penalize for lack of references but rather when this occurs it becomes an issue of academic honesty.

Recommendations for the teaching of future candidates

It is important that teacher provide guidance during the entire IA investigation process, and not only when they read the first draft. Some of the problems that teachers could correct early on include multiple independent variables, unquantifiable variables, graphs with scatter data suggesting a curve but students forcing a linear fit, inappropriate units or even no units, and too simple a research question. Teachers could also make sure students include a descriptive title to their investigation, and that students do some academic research to find out the relevant known theory to their own work. A number of investigations could have been improved if the student had this support early on.

Further comments

The majority of schools are doing appropriate IA work and teacher’s assessment is fair. The majority of teacher’s marks were within the acceptable range. Students are working hard. There was a large range of work quality and a wide range of types of investigations, including database, simulations and mathematical models. This is encouraging, and schools, teachers and students have successfully embraced the new IA system. The key to IA success is to have a well-defined and focused research question that is challenging and interesting to the student.

Some topics of individual investigations that earned high marks include: large amplitude pendulums, temperature and the internal resistance of a battery cell, the fate of stars in Ursa Major (database), Hubble's law (database), Rayleigh scattering (physical and mathematical models), transformer efficiency and frequency, RC circuits and manufactures values, magnetic braking of a pendulum, optimal mass of water in a water rocket, limitations of the Bohr model (model and experiment), measuring speed with the Doppler effect, speed of sound through different materials, temperature and the mirage effect. In all cases it was a scientifically interesting and well-focused research question along with competent analytical skills that earned high marks, not a particular topic.