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Scientific Studies

2015 Chief Assessor’s Report

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## Overview

Chief Assessors’ reports give an overview of how students performed in their school and external assessments in relation to the learning requirements, assessment design criteria, and performance standards set out in the relevant subject outline. They provide information and advice regarding the assessment types, the application of the performance standards in school and external assessments, the quality of student performance, and any relevant statistical information.

## School Assessment

**Assessment Type 1: Investigations Folio**

As with previous years, it was common for schools to include two practical investigations and one issues investigation in this assessment type for the 20-credit subject. It was noted that a diverse range of practical investigations were conducted across the many classes and that the more successful classes were those that followed a theme that linked all of the assessment tasks.

Folio tasks that allowed for ease of identification of student evidence of a performance standard within specific features led to a higher likelihood of grade confirmation at moderation. If a task sheet indicates that a specific feature is to be assessed and there is no evidence of the student (or in some cases a whole class) having addressed this specific feature, yet the teacher has provided a grade, the process of confirming grades is compromised.

Clear, informative task sheets that indicated the specific features to be assessed supported students to demonstrate evidence that was appropriate to the task. Tasks that encouraged students to explain and discuss, rather than simply state information, led to higher levels of achievement, as students were able to demonstrate the analysis and evaluation specific features, as well as knowledge and understanding.

Practical Investigations

Practical tasks that allowed students to individually design investigations, report quantitative data, and then analyse the data with respect to scientific concepts, errors, accuracy, and improvements before drawing a conclusion were most successful. The task design of practical activities must ensure that, regardless of the topic, teachers are able to competently assess the specific features in relation to the performance standards.

The majority of teachers have adapted their practical investigations to allow students to address performance standards specific to practical design, reporting, discussion, and evaluation. Tasks that request students to answer questions that relate to the concepts often limited the ability of students to analyse the data or evaluate procedures. This led to reports that did not address the specific features of analysis and evaluation (AE1 and AE2).

Many students appeared to benefit from opportunities to complete formative practical tasks before submitting summative reports for assessment. Well-prepared students were adept in using standard features of scientific reports, such as the presentation of tables with appropriate headings and units, and correctly formatted graphs. In addition, terms such as ‘random error’, ‘systematic error’, ‘accuracy’, and ‘reliability’ were used appropriately and accurately. Students also benefitted from having opportunities to discuss trends in the data and to link their data to scientific concepts in their reports. Practical tasks that encouraged the use of qualitative data often severely limited students in the reporting and analysis components, and care must be taken in choosing appropriate practical topics for students to investigate to ensure all students have the opportunity to achieve success across all grade bands.

Students are required to design at least one practical investigation themselves. Teachers who included specific feature I1 (‘Design of scientific investigations’) supported students to provide evidence appropriate to investigation design. Feedback on the design is important, as it gives students the best chance of collecting adequate data that is worthy of discussion. A number of teachers have used checklists as evidence for specific features I3 (concerning the use of apparatus) and A3 (concerning work skills). Moderators can confirm grades for these specific features only on the basis of the evidence presented; therefore, it is important to show how the grade was achieved.

Issues Investigations

It is recommended that teachers oversee the topic selection of issues chosen by students to ensure that an appropriate issue is selected. The topic chosen must allow for critical evaluation of the relevant science related to the issue and it must be posed as an argument, to encourage adequate exploration from a variety of viewpoints. This will ensure that students provide more than just background information on a topic.

The information gathered from sources should be evaluated for bias, credibility, suitability, and accuracy. Some students find it helpful to have a pro forma to complete, but the more able students should be encouraged to present their evaluation in different formats that allow for more depth and less repetition without using an excessive number of words within the maximum word count. An example of an annotated bibliography is available on the Scientific Studies minisite. Teachers are encouraged to provide feedback to students regarding the choice of quality sources, as well as how to cite both in text and within a reference list. It is recommended that students submit a draft to a teacher, as this allows teachers to provide feedback on progress and it is one way for teachers to ensure that content is written in the student’s own words.

When assessing specific feature I2 (concerning critical selection from a range of sources), students are encouraged to use reliable peer-reviewed articles, government websites, and scientific journals, as well as other credible primary sources.

Assessment Type 2: Skills and Applications Tasks

Many teachers successfully carried the theme used in the investigations folio throughout this assessment component, such as environmental science, human biology, the physical world, or human movement. The variety of assessment tasks used within this assessment type was quite varied and teachers are encouraged to use tasks that best meet the learning needs of the students in their classes.

Best-practice tasks provided some opportunities for students to answer questions that requested students to list, describe, state, or recall; however, the tasks also included questions of increasing complexity (e.g. to evaluate, explain, interpret, or suggest), allowing students to demonstrate achievement at all levels of the performance standards. Tests remain a common component of this assessment type; however, the design of these tasks often heavily reflected knowledge-recall-type questions and teachers are reminded to ensure that higher-order thinking skills are represented to allow students the opportunity to achieve in the A band in relation to the performance standards. Interpretation and analysis of unfamiliar diagrams or sets of data presented in different forms, when used successfully, provided opportunities for students to meet the highest levels of the performance standards.

Teachers are reminded (as indicated in previous Chief Assessor’s reports) to submit marked skills and applications tasks that explicitly display how grades were derived. Each task should display evidence of student achievement against performance standards, as this assists in the moderation process, which seeks to confirm teachers’ assessments.

In the case of a student completing a model, poster, or PowerPoint presentation that has an oral presentation component, teachers are encouraged to include a transcript or printed copies of PowerPoint presentations (4–6 slides per page) wherever possible. Evidence of specific feature A3 (‘Demonstration of skills in individual and collaborative work’) was easy to identify when a checklist of individual and group skills, and a reflection of the group process were included as part of the evidence. In some instances, teachers included a USB drive containing a video of an oral presentation. Teachers should ensure that individual students and/or individual student files are clearly identified on USB drives or DVDs. The SACE website contains information regarding the submission of electronic files.

Teachers are reminded that they do not need to assess each specific feature within every task. The more successful classes used a less-is-better approach. If the students are assessed on a particular specific feature, such as I2 (on critical selection from a range of sources), then all students must be assessed on this specific feature in that task. If teachers find that a specific feature they had intended to assess in a particular task does not fit the task, then they must include an addendum to the learning and assessment plan and explain why changes were made. Additionally, if changes are made to the teaching and learning program, teachers should go over their tasks to ensure all specific features are addressed and that the course still meets the requirements.

## External Assessment

Assessment Type 3: Practical Investigation

General Comments

The practical investigation remains the most heavily weighted single assessment task in the Scientific Studies course, being 30% of the overall assessment. Despite this fact, it is apparent that not all students are afforded the opportunity to undertake or complete this task to the best of their ability. While the quality of reports continues to improve, the choice of investigation topic can have a restrictive effect on students who are potentially striving for an A or a B.

Teachers are strongly reminded to avoid narrowing the choices of investigation topics available to their students to a particular theme, e.g. rate of reaction, fermentation, photosynthesis and catalase, or vitamin C, for which a range of practical investigations were submitted. Although these topics are quite legitimate, the experiments *must* be entirely student-directed, which includes the choice of topic and all of the design aspects. In some instances, all students in an assessment group conducted the same practical but with a different independent variable, which affects the integrity of the design component assessed as specific feature I1. This practice should be discouraged as it is very hard to assess a proposal when the entire class or large numbers of students submit identical methods, except for the independent variable. Teachers are therefore discouraged from providing heavily scaffolded task sheets where students simply follow a recipe-style investigation for this assessment type.

An additional concern is that simulation practicals were again noted among the practical investigations. The consensus of markers is that simulation practicals *do not* fit well within the concept of practical investigations, as described in the subject outline for Scientific Studies. Simulations deliver pre-determined values derived through the use of a computer program and therefore limit student achievement in relation to the analysis and evaluation specific features.

The increased use of psychology-based investigations was evident among the practical investigations assessed this year. While these types of investigations often produce data, it is most often quantitative subjective data; that is, the data is based on the opinion of subjects involved. In Scientific Studies, however, students are more able to provide good evidence of analysis and evaluation using quantitative objective, that is, measured data, rather than data based on opinion.

On ethical and safety grounds, investigations involving potentially excessive consumption of caffeine or other stimulants in various forms should be regarded with great caution.

In summary, teachers have the responsibility to ensure that all investigations undertaken within their classes are of an appropriate standard and quality for this Stage 2 subject. They must also allow students to safely and ethically conduct experiments over a wide range of topics and ensure that students are provided with every opportunity to achieve in the A band for this assessment task.

When the design component is closely monitored, when students have a strong grasp of the scientific concepts, and when both the reporting and analysis sections are competently detailed, then the choice of topic will lead to successful practical reports being produced. However, students with limited scientific background knowledge struggled to achieve well in topics related to rate-of-reaction practicals (particularly enzyme-based reactions), photosynthesis/wavelength experiments, and bacterial investigations. Teachers are advised to ensure adequate background knowledge is offered to students before the students individually design their experiment to avoid common design flaws, such as the lack of replication necessary for an adequate sample size, and limited opportunity to analyse and evaluate findings.

It was apparent that the time available for doing experimental work and writing it up varied dramatically, ranging from one lesson to do the experiment and about 2–3 weeks to write it up, to several lessons over a couple of weeks and 1–2 months to hand in the final piece of work. This variation significantly affected the overall quality of the report; for example, the shorter timeline limited opportunities for replicates to be collected so that averages could be generated and sources of errors adequately discussed. It would seem that very short timelines are inadequate for the external component worth 30% of the final grade for Scientific Studies. However, teachers should avoid excessively long timelines, as these may encourage students to devote too much time to the investigation, not commensurate with the marks available.

The use of headings and subheadings within the report is highly encouraged, as this not only assists students in structuring their responses appropriately but also helps them in meeting the criteria of the task.

Teachers are reminded, that teacher marks or comments must not appear on or be attached to student reports submitted for external marking. Finally, care must be taken to ensure that neither the school name, nor school SACE number, nor the student’s name appears anywhere within the report.

Proposal

Concern was expressed by the marking panel where submitted proposals were identical to the final version of the method submitted within the report. It was not clear whether the proposal was the original version or the edited version or perhaps even a version prepared after the final report was completed. It was noted that in cases where the original proposal contained flaws, some of the resubmitted proposals appeared to contain little or no corrections in the final report. Some investigations lacked a proposal.

The insistence of detailed background information at the proposal stage is *not* required and it is more important for students to link the relevant background information to the analysis of their results.

Risk assessment featured strongly in many investigations to the point where the assessments were excessive in length and in many cases referred to simplistic risks, such as removing a splinter from a finger. It is unnecessary to discuss such risks. Students should also be mindful that presenting their risk assessment in a table still leads to the table’s words being incorporated in the word-count.

In order to maintain the integrity of this assessment task, teachers cannot allow students to simply copy a method previously used and submit it as their own work.

Introduction

There is no requirement for a student to provide an abstract in their report. While an introduction is useful, care must be taken to ensure that it is succinct and relevant and referred to during the analysis of their data. With both the abstract and the introduction, valuable words can be wasted that are better used elsewhere within their report, particularly in the analysis and evaluation section.

Design

Writing a hypothesis is difficult for some students. Evidence was noted of poorly worded hypotheses that (a) failed to link an independent variable with a dependent variable, (b) provided two independent variables, or (c) linked one independent variable with two dependent variables.

It was also noted that some hypotheses were too simple (e.g. temperature versus dissolving), suggesting that the quality of the investigation was likely to be inadequate.

The method component, for the most part, was well prepared, with many students detailing the materials needed and listing the procedural steps employed. However, using paragraphs in this section is not the preferred way of outlining the method; better quality responses used a set of procedural steps.

The need for an adequate sample size in investigations is important and warrants considered attention. In order to be able to discuss the accuracy of their data, students require replicates of data and teachers are advised to provide adequate feedback concerning sample size to students after the submission of the original design proposal.

In instances where classes conducted experiments in pairs or groups, student achievement was often limited, as individual practical reports that reflect student achievement against performance standards is required. Additionally, teacher-directed topics that contained extensive information in an introduction and diagrams in the method made it difficult for the markers to discriminate between what was provided by the teacher and what was the work of the individual student.

Students are assessed against I1 (‘Design of scientific investigations’) in the practical investigation. Individual student evidence of the experimental design must be provided for students to be assessed against I1.

Results

Students who achieved in the A band for this component provided replicated data that was displayed within summary tables and graphs with accurately stated variables within headings. Additionally, these students included all calculations so that markers could easily identify what the data was representing. In order to communicate scientific data accurately, students should avoid copious amounts of tables and graphs which would be better displayed as summary tables and, where warranted, by combined graphs. Raw data is best included as an appendix.

Where multiple data is supplied, the use of averaged results is recommended. However, students must remember that any average listed must contain the correct number of significant figures as determined within their original data.

Students are reminded that the type of data they have collected will determine the appropriate graph format that is required to best communicate their data. If the data is continuous (such as a range of concentrations, times, or pHs) then the data should be plotted as a line graph (showing the points with a line of best fit), whereas non-continuous data (different age groups, or genders) should be plotted as a histogram.

Graphs have often been drawn with programs, such as Excel, where the x-axis has been incorrectly interchanged with the y-axis. This arises from choosing the wrong format for line or scatter plots and detracts from the accuracy of the plotted data.

Where the line of best fit was displayed in graphs, students erred in displaying the wrong type of line; that is, should it be a straight line of best fit or a curved line of best fit? The incorrect application of the line of best fit inherently leads to an inappropriate analysis of the data.

Where multiple related graphs are used, students must ensure that the same scale is used on the y-axis in each graph. Using commercial programs to prepare graphs unfortunately does not ensure that the same scale on the y-axis is always displayed. The subsequent effect is that the shape of a graph can become quite distorted, giving rise to a misleading, perhaps incorrect, interpretation being proposed by the student.

A number of reports are still being submitted as black and white copies, whereas the original graphs and diagrams were in colour. The interpretation of graphs relies upon the ability to accurately distinguish the lines and this sometimes cannot be discerned in greyscale.

Some investigations included qualitative results only. For example, experiments involving micro-organisms were just ‘qualitatively’ analysed by photographs, whereas than the zones of inhibition of bacterial growth, or the height/volume of foam produced by fermenting yeast, can actually be measured to provide quantitative results, thus enabling much better analysis.

In a number of investigations involving micro-organisms, the ability of students to identify specific bacterial species on the basis of colour and colony morphology must be questioned. Such an assessment is extremely unreliable, as the only real way to identify such micro-organisms is through conducting various biochemical tests. It is highly unlikely that schools have the appropriate facilities for such tests.

Analysis and Evaluation

The analysis and evaluation sections for a number of students were very heavily scaffolded, as the layout and phrases, and sometimes sentences, were often identical across a class. While some form of scaffolding is appropriate, elaborate and detailed scaffolding rarely allows students the opportunity to analyse and evaluate their data in a highly effective manner.

In numerous cases, instead of providing little more than a regurgitation of raw data, detailed analysis of data may have generated a different outcome for students to consider. In some cases, detailed analysis may have actually confirmed a student’s hypothesis rather than refuting it. For example, students who accurately repeated an experiment with replicates negatively affected their grade by then not generating an average.

Responses in the analysis of students’ data highlighted that many students were not fluent with the concept of outliers, where they may exist within their data, and what the implication of outliers may have on the analysis of their data.

A consistent problem in this section was the lack of understanding of random and systematic errors. In conjunction with the discussion of random and systematic errors, the incorrect usage of the terms ‘accuracy’, ‘precision’, ‘scatter’, and ‘reliability’ was often evident. It is acknowledged that random and systematic errors are present in every investigation; therefore, for students to declare that no systematic errors were present clearly indicates an incomplete knowledge of errors.

All practical investigations require a suitable sample size to help verify results obtained within the investigation. This practice will reduce the effect of random errors through averaging of the results, as well as the opportunity for the investigation to be repeated, which takes into account whether systematic errors were present or not.

While students may not have the opportunity to repeat their investigation, they should be able to address the sample size issue within the investigation. It was noted that many students performed their investigation once only, while others had relatively small sample sizes. In both cases, the final sample size was minimal and inadequate.

Discussing possible improvements for the investigation was noted in most reports. However, many students do not seem to be fully aware of what ‘appropriate improvements’ means, let alone be able to discuss why. Often, a listing of possible improvements is all that was provided and this restricts student achievement.

As alluded to earlier within this report, the choice of investigation topic had the ability to severely hamper students, as quality improvements for their specific investigation were not always possible given the simplistic nature of their original investigation.

Given that analysis of data, specific feature AE1, is just as significant as all assessed specific features, it is essential that students demonstrate their ability to find patterns in their data and link data with scientific concepts. Overall, not enough evaluation of results was evident in many reports.

Conclusion

Students are reminded to ensure that they use a conclusion section in their report to address the specific feature AE1, which refers to formulating a conclusion. Students should discuss whether the data they collected supports or refutes the hypothesis.

## Operational Advice

School assessment tasks are set and marked by teachers. Teachers’ assessment decisions are reviewed by moderators. Teacher grades/marks should be evident on all student school assessment work. The teacher grades/marks assist the moderation panel in confirming assessment decisions.

Variations — Moderation Materials forms were not always submitted when tasks were missing; this made it difficult to determine how a student’s final grade had been derived. The form should clearly identify the reasons for missing or incomplete work.

Grades allocated by teachers should reflect the work received and marked by the teacher, as well as the granting of any special provisions, or any reductions in the overall grade due to non-submitted work.

When student materials are packaged for moderation, it is useful for an overall summary of assessment decisions for all tasks, indicating the specific features used, to be included. Teachers are reminded not to include folders or additional plastic sleeves.

Neither the school name or number, nor the student’s name, must appear anywhere in the report. Students should be identified only by their SACE registration number.

## General Comments

Teachers are encouraged to attend a clarifying forum to become more familiar with performance standards and task design and to use information provided on the Scientific Studies minisite.

Teachers are encouraged to provide sufficient opportunity for critical analysis in their task design, and to examine their tasks to ensure that students are asked to use higher-order thinking skills in summative tasks.

Teachers are reminded to ensure that they retain student work throughout the year so that the work is available as evidence for moderation at the end of the year.

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