GCSE SCIENCE EXAMINATIONS 2008, 2009 AND 2010

SUMMARY REPORT

COMISSIONED BY:

ASSOCIATION FOR SCIENCE EDUCATION, INSTITUTE OF PHYSICS, ROYAL SOCIETY, SCIENCE COUNCIL AND SOCIETY OF BIOLOGY

BACKGROUND

In 2006, a new set of GCSE science specifications was introduced by the four unitary awarding bodies (now referred to as awarding organisations) – AQA, Edexcel and OCR in England, and WJEC in Wales. The specifications were designed to provide a greater range of options for students taking GCSE science, both through the approach to the specification and the methods of assessment.

Thus, in 2008 and subsequently, students could be entered for science-related GCSEs in the following ways:

- a combination of GCSE Science (the minimum or 'core' requirement to satisfy National Curriculum legislation) with, optionally, either GCSE Additional Science or

  GCSE Additional Applied Science; or
- all three of: GCSE Biology, GCSE Chemistry, GCSE Physics; or
- GCSE Applied Science (Double award).

Students could attempt either foundation or higher tier papers in all the specifications. In addition, an awarding organisation could provide more than one GCSE specification or an individual specification could have more than one method of assessment (for example, multiple-choice papers as an alternative to written papers).

Key players in the science education community[1], therefore commissioned research through SCORE to provide information on the 'fitness for purpose' of the new GCSE science examinations, of all the specifications, across the four unitary awarding organisations in England and Wales. (The awarding organisation, CCEA, in Northern Ireland does not follow the same model and therefore did not come under the remit of this project and Scotland has an entirely different system.) The research appraised the GCSE science examination papers from the years 2008, 2009 and 2010.

AIMS

The overall objective of this research was to inform the organisations about the standards associated with GCSE science examinations so that they can make effective input to MPs, government bodies including the Department for Education (DfE) and the regulatory body Ofqual, and to the awarding organisations. This is a complex area and in order to focus the research the scope of the work was deliberately kept narrow, and covered five broad areas.

1. Accuracy of the science: whether the science in the examination questions and in the mark schemes (where available) was accurate.
2. Knowledge required: whether any questions could be answered without any knowledge of science or use of scientific skills.
3. Mathematics: the extent, type and level of mathematics needed, and whether this was the same across the awarding organisations.
4. How Science Works: the way in which How Science Works was assessed.
5. Question type: the balance between responses required for various question types in the examination papers.

The research looked at the performance of assessment rather than being an assessment of performance. The assessment of both coursework and specification coverage were outside the scope of this project.

[1] The Association for Science Education, Institute of Physics, Royal Society, Science Council and Society of Biology

METHODOLOGY

The methodology was essentially the same each year, although there were some refinements year on year. A Working Group of 15–18 experienced biology, chemistry and physics teachers, examiners and scientists (from universities and industry) analysed the following GCSE science papers, foundation and higher tier, from AQA, Edexcel, OCR and WJEC:

- the 2008 Science and Additional Science papers. In total 79 papers were analysed in March 2009;
- the 2009 separate science papers (paper 3s) and the Additional Applied Science papers (only AQA, OCR(A) and WJEC specifications have the latter papers). In total 47 papers were analysed in April 2010;
- the 2010 Science, Additional Science and separate science papers. In total 129 papers were analysed in August 2010.

The participants, many of whom took part in all three analyses, recorded their findings and comments on analysis grids similar to those used by the awarding organisations in setting examinations.

The data and comments from the grids were collated to provide a summary for each examination within each specification. Consultants acted as moderators to resolve any major disagreements or disparities on the grids, but made no attempt to average the scores. This helped to identify areas where there was good agreement and where judgements were more problematical.

KEY FINDINGS

ACCURACY OF THE SCIENCE

The vast majority of questions in the 2008 and 2009 examination papers were correct at the level examined. (The mark schemes for the 2010 papers were not available in time for them to be analysed.)

Across examination papers analysed, there was some concern that 'allowable' answers in some mark schemes did not reflect correct science. The participants in the Working Groups reasoned that this might encourage incorrect teaching, especially by subject non-specialists. However, one awarding organisation exemplified good practice by providing clear and helpful mark schemes and the participants agreed that the provision of such a model set of answers, or a candidates' mark scheme, would help to ensure that subject non-specialist teachers use correct science. 'Allowable' answers could then be restricted to examiners' comments in their reports.

There were also some examples where inaccurate pictures and unnecessary information were included in the questions, which were unhelpful and more of a distraction.

KNOWLEDGE OF SCIENCE

There were very few instances across all the specifications when neither a knowledge of science nor of How Science Works was needed to answer some parts of some questions. Overall, the proportion of questions which required no knowledge of science had dropped over the three years. In the main, such questions required basic English comprehension – eg a small section of text was given containing three to four facts, and the questions required the regurgitation of these facts – and was used predominantly by one awarding organisation.

The remaining handful of questions that could be answered with apparently no knowledge of science were low-demand questions in foundation papers. For candidates working at this level such questions could, however, be interpreted as requiring 'scientific skills', eg extracting scientific data from tables. Inevitably, the participants agreed, for questions to be accessible to the least able on the foundation tier they sometimes have to be phrased in a way that some might construe as 'Not science'.

The separate science papers, in contrast to Additional Applied Science papers, were found to be good preparation for A-level study in the sciences.

MATHEMATICS

There was a wide variation in the amount and level of mathematics assessed across the disciplines and specifications. There is more mathematics in the Additional Science papers than in the Science papers, and Additional Science and Physics papers contain more higher demand mathematics (ie taken from the National Curriculum Key Stages 3/4 Mathematics Programme of Study) than Science, Chemistry and Biology papers.

While there have been modest increases to the amount of mathematics required in science exams over the three-year period of this research, much of it, including that in the separate science papers, is at Key Stage 2. Overall, the demand and type of the mathematics within all papers were found to be limited when compared to the lists of required mathematical operations provided by some awarding organisations in their specifications.

The amount of Key Stage 2 mathematics is a consequence often of whole number operations being used in science questions. There seems no reason why awarding organisations don't include 'real world non-integer numbers' in science questions for candidates to manipulate. This would be more realistic and would require the candidates to use mathematics from Key Stages 3/4.

Some awarding organisations place much less reliance on the use of mathematics in science examinations than others. While this can be explained by differences across subject areas (eg in the more mathematical demands of physics) it is harder to understand why, particularly in the case of Science and Additional Science, that there are such wide variations.

HOW SCIENCE WORKS

The GCSE criteria currently divides How Science Works (HSW) into 'Methods of science' – eg practical investigations, data and their limitations, correlations, the testing of scientific theories etc – and 'Science in society' – eg the implications of science and technology on the environment and on people, risk assessment and the role public bodies have in assessing and regulating risk, peer review etc.

Overall HSW was assessed more on Science (core) papers than on any of the other papers, but in nearly all specifications there was more emphasis on the Methods of science than on Science in society. This is despite the fact that the GCSE criteria require HSW to be assessed and does not distinguish between the amount that has to be assessed from the two strands.

There was also generally much more variation in the awarding organisations' interpretation of Science in society and of its importance in the assessments. There has been little to no improvement in this over the past three years even though Ofqual called for more assessment of the broader aspects of HSW in its 2009 and 2010 reports on GCSE science examinations.

There were significant differences found between awarding organisations in terms of the amount of assessment of HSW (ranging from ca 3% to 25%) and its distribution between the different examinations. Some of these differences, which were evident in both foundation and higher tier papers, may reflect differing emphases within different specifications. However, the average percentage marks awarded for HSW within a particular specification were broadly similar for both foundation and higher tier papers.

Overall, there has been little change over the past three years in the amount of assessment of HSW or its distribution. If anything there has been a reduction, particularly in the case of physics. Further there is no evidence of alternative means of assessing HSW – particularly the Science in society aspects – despite pressure from Ofqual to do so. Some participants suggested the use of extended essays as one way of addressing this .

QUESTION TYPE

The question types for this study were categorised as:

- short answer (SA) – ie a letter or number or tick, including multiple-choice;
- continuous prose (CP) – ie a phrase or one sentence;
- extended prose (EP) – ie more than one sentence, usually two – three.

The two Ofqual reports published in 2009 and 2010 on GCSE science examinations called for the use of more extended prose questions compared to multiple-choice questions so that students can demonstrate the extent of their scientific knowledge, understanding and skills.

Over the three-years of this research, however, there has been only a modest increase in the amount of extended prose required in the science examinations. The figures show that less than one mark in three on the separate science papers and sometimes one mark in five on Science (core) paper is given for extended prose. This does not allow the more able students to show what they know and can do, including bringing together scientific ideas in a synoptic manner.

In general the research found:

- there are significantly more marks associated with short answers on foundation papers than on higher tier papers, but more marks for extended prose on the higher tier papers than on the foundation papers;
- there are differences in the proportion of marks associated with short answer questions (ranging from 38% to 68% in the 2010 papers) and extended prose (ranging from 16% to 32% in the 2010 papers) between the awarding organisations. One awarding organisation, in particular, has a much greater amount of extended prose in its separate science papers, which as a consequence allows the most able students to demonstrate what they know and can do;
- there are differences in the proportion of marks associated with short answer questions between specifications, with significantly more marks associated with short answer questions in Science (core) papers. For example, 65% of the questions in the 2010 Science papers required short answers, whereas on average 40% of the questions in the 2010 separate science papers required short answers.

CONCLUSIONS

This report reviewed the examinations from 2008-2010, and there are some consistent findings across the three years, including:

- the question types used provided insufficient opportunity for more able candidates, particularly those at higher tier, to demonstrate the extent of their scientific knowledge, understanding and skills. The question types restricted the range of responses that candidates could provide. There was little or no scope for them to demonstrate various aspects of the Assessment Objectives and grade descriptions;
- there are examples where the science being assessed did not depend on candidates engaging with the context addressed, so that this context was in fact unnecessary;
- the use of mathematics in science was examined in a very limited way, both in terms of the quantity and demand of the questions;
- Ofqual calls for the need in future specifications for alternative methods of assessing How Science Works. There is no evidence from this research of a move towards this in the written examinations.

The findings of this report are consistent with those of Ofqual's recommendations in its 2009 and 2010 reports[2,3].

[2] The new GCSE science examinations. Findings from the monitoring of the new GCSE science specifications: 2007 to 2008, Ofqual March 2009
[3] Review of standards in summer 2009 GCSE Science and GCSE Additional Science, Ofqual, July 2010

Credit: Dr Colin Osbourne

The work for this report was carried out in 2010 and the report written in 2011.