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SCIENCE COMMUNITY REPRESENTING EDUCATION

Assessment of practical work in science

Summary of a seminar organised by SCORE
at the Royal Society, 16th November 2009.

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This is a report of a SCORE seminar held on 16 November 2009 at the Royal Society. The report summarises the main issues raised and describes views presented at the meeting.

1. Background

In 2008, SCORE published *Practical work in science: a report and proposal for a strategic framework* which examined the state of practical work in science in the UK during 5-19 education. SCORE made a number of recommendations, some of which, such as improving CPD for teachers, are being addressed through the *Getting Practical* project led by the Association for Science Education (ASE). SCORE continues to address the other recommendations and develop policy in this area. This seminar aimed to discuss the purpose and methods of assessing practical work.

2. The seminar

The seminar was chaired by Annette Smith, Chief Executive of the ASE. An introductory presentation was given by Martin Hollins (Education Consultant) on the history of the assessment of practical work in schools in the UK.

Presentations were made by three teachers who each had recent experience of assessing practical work: John Charlesworth, Head of Science and Joint Director of Studies, Sibford School; Kris Sutchbury, Subject Leader for Science, Open University PGCE; and Marian Mulcahy, Deputy Head of Science, Longsands College. The teachers explored how practical science is assessed at GCSE by the English awarding bodies, how this works out in practice in schools; and the implications of the assessment methods for the development of classroom practice.

A plenary session widened discussion to include: mathematics in science, teacher CPD; the purpose of practical science in schools and the industrial perspective.

Around 50 teachers, representatives of learned societies, representatives from examination boards, academics, industrial representatives, education consultants and SCORE partners participated in the seminar.

3. The purpose of assessing practical work in science

Practical work in science has several purposes including: practicing skills, developing specific knowledge and understanding of science, and developing an understanding of the processes of scientific enquiry. Given this, it was suggested that it would be desirable for practical assessments to give students the opportunity to:

- carry out a range of experiments with varying degrees of difficulty to allow discrimination between candidates.
- analyse and evaluate given results demonstrating their knowledge and understanding of the processes of scientific enquiry – noting that the assessment of these skills should be completely separate from the assessment of practical competencies.
- demonstrate how to sensibly plan an investigation, with due consideration for safety, reliability etc.

Hence practical work is used to assess procedural skills and understanding the scientific process.

4. The current GCSE science specifications

The current GCSE science specifications were introduced in 2006 and there are key philosophical differences between them.

The OCR specifications (21st Century and Gateway) are grounded in the work of Robin Millar from the University of York, with an emphasis on promoting scientific literacy[1]. The coursework assessment consists of analysis of a contemporary science issue,

[1] R. Millar and J. Osborne, 1998, *Beyond 2000,* London: Nuffield Foundation and R. Millar, 2006, *Twenty First Century Science: Insights from the Design and Implementation of a Scientific Literacy Approach in School Science* International Journal of Science Education, Vol. 28, No. 13, 1499-1521

a broad range of practical tasks, an opportunity to analyse data and draw meaningful scientific conclusions from it, and a research based investigation.

AQA and Edexcel courses are based on the work of Richard Gott from Durham University with an emphasis on the role of evidence in scientific enquiry[2]. Their internal assessment is entirely based on practical work and consists of practical skills assessment and tasks set by awarding boards.

A summary of the internal assessment requirements of the 2006-2011 specification is provided in Table 1.

Table 1: Internal assessments in the 2006-2011 GCSE science specifications

Specification		OCR 21st century	OCR Gateway	AQA	Edexcel
Core	**Total % internal assessment**	33%	33%	25%	40%
	Assessment tasks	*20% Case study* (May not be practically based) *13.3% Data analysis task.* Based on primary data; collection of the data is not assessed	*Science in the News* (Not practically based) *Can-do practical tasks* **OR** *Research task, Data analysis, Practical skills*	*ISAs* Written tasks based on a practical done by the student **PLUS** *Practical skills assessment*	*ISS* 3 written tasks based on practical work **PLUS** *Teacher-assessed practical skills mark*
Additional science	**Total % internal assessment**	33%	33%	25%	40%
	Assessment tasks	*A complete investigation*	*Research task, Data analysis, Practical skills*	As above	As above
Additional Applied science	**Total % internal assessment**	50%	n/a	60%	n/a
	Assessment tasks	*16.7% work related report* (not practically based) *21% practically based suitability test* *12% standard procedures*	*Practical*	*20% Science in the workplace* (portfolio) *40% Using Scientific skills* (portfolio)	

[2] R.Roberts and R.Gott, 2006, *The role of evidence in the new KS4 national curriculum for England and AQA specifications* School Science Review, Vol. 87, No. 321, 29-39

4.1 OCR - 21st Century Science and Gateway Science

One of the key strengths of the OCR practical assessment model was felt to be that it reinforced the learning objectives of the rest of the course and that it was delivered as an inclusive component. The OCR model also requires students to carry out a substantial amount of non-assessed practical work in order to develop the necessary skills to succeed.

The internal assessment in 21st Century Core Science has two components: a case study, teaching the skills of evaluation and understanding the science behind the activity, and a data analysis activity. The experience of the teachers presenting at the seminar suggested that students find both aspects quite challenging and that they benefit from undertaking a lot of practical work prior to the internal assessment.

Students studying OCR's Gateway Core Science can either be assessed using practical tasks or a Science in the News task. Teachers noted that the Science in the News task is a popular element of the course. The presentation did however question the extent to which this task assesses students in practical work. Alternatively, students can carry out week long research tasks and a data analysis task. These assess practical skills through experiments which are integral to the course. It was commented that one of the advantages of Gateway practical assessment was that students were exposed to a range of practical techniques across the sciences.

4.2 AQA

The rationale of the course, and the marks during the assessment, are given for the procedural understanding of the experiment as well as for practical skills. The Individual Skills Assignments (ISAs) involve a series of short tasks, set by the awarding body that support teaching and learning in science and aim to keep the assessment simple, fair and reliable.

Teachers reported that work to support success in the ISAs is relevant to the main written examination and students who understand science are generally doing well in them; they discriminate well, and better than previous assessment schemes.

A challenge is that opportunities are missed for formative assessment as, owing to security implications, students do not get their work back to see where they went wrong. It was also noted that a considerable amount of reading is required to complete an ISA. Some teachers feel that this discriminates against students who have problems with literacy, especially as only one tier is offered.

4.3 Edexcel

Edexcel has a total internal assessment mark of 40% involving 3 practical tasks plus a teacher-assessed practical skills mark which is generally given for work over the duration of the course. As with AQA, students undertake a piece of practical work and are then set a written task which is completed under controlled conditions. The tasks can be fitted into the scheme of work at the time they are applicable and are perceived as encouraging practical work. The mark schemes are issued by the awarding body but are generic rather than specific to a particular exercise.

5. Issues

5.1 Assessing practical work in science

It was felt to be very important that practical work should continue to be assessed as part of the GCSE. There were many reasons given for this, but a key one was that assessing practical work ensures that it remains an important part of the curriculum. The pressure of league tables can mean that work that is assessed is prioritised.

Assessing practical work in science also ensures that senior management teams in schools keep practical science funded and technician support available. It was felt strongly by the meeting that to ensure that practical work remained at the heart of the science curriculum, it must continue to be assessed in some form.

5.2 When and where to assess

Some participants recommended that teachers should have the freedom to use the assessed practical at the appropriate point during the course. They noted that assessing practical skills by a written paper could be seen to be incongruous and may lead to senior managers wanting to 'do' all controlled assessment in a separate week, decoupling them from the rest of the course. It was also felt to be beneficial that the assessments should take place in school as it removed the problems of students receiving parental help.

5.3 The teaching workforce

The seminar highlighted the growing role of How Science Works in the assessment of practical skills and the varying degrees of confidence teachers have in delivering and assessing this component.

Good quality CPD for teachers was felt to be necessary, especially to help them link practical work to the analysis of data, and to develop a clear understanding of the purpose of practical work. This is currently being promoted by the Getting Practical programme which delivers professional development for teachers on the pedagogy behind practical work.

The seminar also raised the need for specialist teachers in the sciences, and highlighted the valuable contribution made by those who have experience of actually 'doing' science. There was a general consensus that an increase in teachers with specialist subject knowledge will result in more effective practical work.

5.4 Science in the workplace

Considering the requirements for people entering the work place, it was noted that not all scientific roles need a science degree; there are many roles in which being able to carry out procedures accurately is important.

Industry representatives felt that the assessment of practical work in science needs to credit students' procedural skills. It was also felt to be important that they are able to recognise when a result is anomalous, think of reasons why that might be and decide when measurements ought to be repeated.

5.5 Mathematics in Science

When analysing results of experiments it was agreed that students should have to demonstrate use of mathematics and mathematical skills. At present those required are thought to be limited. It was seen as a positive step that real data is now being used in the assessment of practical work and that the emphasis is on understanding concepts such as reliability, accuracy and validity.

5.6 Variation between awarding bodies

The variation between awarding bodies was seen as perhaps being a cause for concern; both in terms of what should be included in coursework and in how it should be assessed. However, many teachers seem to value the opportunity to make a genuine choice. Teachers who have adopted 21st Century Science, for example, often feel very strongly that they do not want to do tasks set by the awarding body as part of their assessment procedures. Likewise, teachers who have opted for AQA or Edexcel are not always enthusiastic about the requirement to undertake case studies with the implications for marking and access to ICT.

There was also concern expressed that not all current specifications assess students' ability to plan scientific investigations. It was acknowledged that developing a rigorous method of assessing this skill has been problematic. For example, students may have been asked to 'plan' an investigation similar to an experiment they had recently carried out and hence a genuine understanding of the planning process was not assessed. There was a suggestion that a solution might be to ask questions to which there is no single answer but which are still scientific.

6 Summary

It was agreed that practical work is an integral part of science and should therefore be assessed as part of the public examination system. The issues that emerged in the seminar were:

- The differences between examination boards. Should teachers be offered a choice or should there be consistency across the provision?
- What is an appropriate balance between the assessment of practical skills and the assessment of understanding the processes of scientific enquiry?
- Should coursework be more than just practical work and include project-work such as case studies or 'science in the news'?
- Practical assessments need to be valid and reliable. Is this best achieved through tasks based on real experiments or by giving students the opportunity to carry out their own investigations?
- How can planning be assessed sensibly?

SCORE partners will continue to engage with awarding bodies, QCDA and Ofqual on the assessment of practical work in science, as well as developing policy advice in this area.