The assessment of practical science: a literature review

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1 Introduction

This project reviewed the literature about the various ways in which students' skills in practical science are assessed, and could be assessed. Information from education journals, science education bodies in the UK, overseas experts and examination boards was collected. Examples of different ways of assessing practical science from England and from high-performing jurisdictions were collected to illustrate how different types of assessment may be implemented. Internationally, practical skills form a key part of most science curricula, and thus the assessment of practical skills is a crucial aspect of the validity of science qualifications. However, the recent introduction of 'controlled assessment' for practical science in England has been criticised because of a perceived overload of teacher assessment, arising from the teaching and administrative time which this form of assessment requires.

2 Purposes of practical science in the upper secondary years

There is broad agreement about the purposes of science practical work in a programme of teaching and learning. There is a consensus in the science teaching profession that the main purpose of practical work is formative; that is, it assists students to understand the science which they are studying, and how scientific ideas are developed.

Some purposes of practical work commonly listed include:

1. Motivation for students – the excitement of discovery
2. Consolidation of theory
3. Development of manipulative skills
4. Knowledge of standard techniques
5. General understanding of data handling
6. Development of other skills (eg analytic, evaluative, planning, applied, mathematical)
7. Understanding of how science works (eg concepts of scientific process, collaborative working, reproducible results, fair testing)

However, there has been some serious questioning of the efficacy of work done in science practical lessons. There is also a consensus that the type of isolated practical tasks carried out for assessment purposes at GCSE do not enable students to find out how scientific enquiry really works. As such, the forms of summative assessment currently used at GCSE are considered not to support the aims of practical science.

3 Describing practical science assessments

Key thinkers on science education frequently focus on the pedagogy of the subject rather than on its assessment. Furthermore, the fact that the main aim of practical science is considered to be pedagogic leads to a difficulty in defining what should be assessed in a summative examination. The skills which are assessed are typically narrower than those skills which practical work aims to develop. It is therefore desirable to ensure that curricula and assessment are designed in parallel. There is, however, concern that even though the current arrangements for assessing practical work at GCSE are considered unsatisfactory, formal assessment of practical work is necessary to ensure that practical work remains a priority.

Eight criteria for describing practical assessments were developed which could be applied to any scheme, whether externally administered or school-based:

1. Place in the overall assessment scheme or exam
2. Practical skills to be assessed
3. Task types / activities
4. Responsibilities for setting / selecting practical tasks
5. Organisational requirements for centres
6. Evidence to be provided by students, eg exam answers, lab notes, project report
7. Responsibilities for prime marking
8. Moderation and Quality Assurance

A typology of seven kinds of science practical assessment tasks was also developed:

Type One: Traditional practical task or examination (multi-step)

Type Two: Written examination (not involving work in a laboratory directly) which assesses practical skills

Type Three: Investigations

Type Four: Projects

Type Five: Skills-focused assessments, ie which address the kinds of laboratory skills that science practical work will require

Type Six: Portfolio of required, teacher-run assessment tasks

Type Seven: Classroom-based, coursework assessment

4 Reflection on types of school-based assessment

A wide variety of assessment types are currently being used for the assessment of science practical work. These include innovative schemes of investigation and project work, as well as more traditional assessments of specific laboratory skills. However, the more complex the assessment tasks, the more complex they become administratively. Some examples of portfolio assessment schemes demonstrate the tendency for public examination systems to become regulation-bound and restrictive.

Constraints are imposed on the assessment of practical skills by the procedures which are required to ensure standardisation when a subject is assessed as part of a national examination scheme. These constraints can undermine the pedagogical aims of practical science. For example, concern about continuous assessment tasks may divert attention from learning towards the demands of the assessment.

5 Reducing the amount of school-based assessment

The Department for Education in England has proposed that school-based assessments should be reduced or dropped due to concerns about reliability, authenticity and teacher- and student-workload. Similar concerns have been noted in jurisdictions where ambitious school-based assessments for practical science have been introduced. Despite this, there is still support among the science teaching community for school-based assessment. It has been proposed that some practical skills, such as processing and presenting data, may be assessed effectively using a written examination paper. So it would be possible, and indeed beneficial, to reduce the range of skills which are assessed using internal assessment.

6 Conclusions

Internationally there is widespread agreement about the importance of practical work in science. However, the pedagogical benefits may be undermined by the procedures which are needed in the context of a national examination system. This review identified several different ways of assessing practical work in science but found that caution is necessary to ensure that the learning objectives are not overwhelmed by the need to complete assessment tasks. Now therefore may be an opportune moment to alter the amount of time that must be spent on science practical work for public examinations. Practical work of all types should be encouraged during the science course, but the time spent on assessing it could be reduced.