A longitudinal survey of teachers' attitudes to the reform of GCSE and AS/A-level sciences, 2015–2017

Tony Leech, Neil Wade, Frances Wilson and Steve Evans

Abstract In England, GCSE and AS/A-level practical assessment has been reformed, with controlled assessments replaced with practical assessment in written exams and direct assessment at A-level. The awarding body OCR surveyed science teacher attitudes to the reform during its introduction. Teachers considered post-reform qualifications better in that they allowed for a wider range of activities and had a positive impact on teaching and learning of theory. The need to offer assessed practical work was no longer seen as a challenge to effective practical delivery. Views of the purposes of practical science, its characteristics and other challenges to it remained relatively constant over time.

Recent years have seen reforms to GCSEs and AS/A-levels, the major school qualifications in England. The sciences (primarily, biology, chemistry and physics) are no exception. Reformed A-levels in science were first taught from 2015 and assessed in 2017, while reformed GCSEs, including a new double combined science award replacing previous core and additional science qualifications, were introduced a year later, being first taught in 2016 and assessed in 2018.

Notable features of the reformed qualifications included new content and changes to methods of assessment. The previous qualifications included controlled assessment, which was made up of a report or evaluation of data from a practical activity set by the exam board, carried out in controlled conditions, and which was worth 25% of overall grades. Partly as a consequence of concerns about the fairness of this mode of assessment, the time it took to deliver, the potential for malpractice and whether it could adequately differentiate between candidates, this assessment was replaced in the reform process (Wade and Abrahams, 2015).

The new courses feature the indirect assessment of practical skills in written exams (where 15% of marks require knowledge of practical skills) and the opportunity for candidates to carry out practical work in lessons. The A-level courses have a Practical Endorsement, based on direct teacher assessment of assignments and reported separately to the main grade. Candidates can receive a pass grade or a 'not classified' result for their practical work.

Alongside other reviews of the reform, including a five-part Ofqual study (Cadwallader, 2019), a longitudinal evaluation programme was set up within the UK awarding body OCR to assess teacher views of practical assessment at both GCSE and A-level, both before and after the new qualifications began. The project involved an online survey of science teachers and department heads, answered in 2015, 2016 and 2017.

This is the second article covering outcomes from this survey. The first (Wilson, Wade and Evans, 2016) introduced the history of practical science in science lessons in England and discussed baseline findings from the survey's first year (2015), the final year before reforms to the qualifications. It focused on the purpose and type of practical work conducted at A-level, and the characteristics of the practical work undertaken in schools.

This article follows on in discussing findings in relation to these issues for both GCSE and A-level, using data from 2015 to 2017. It should be noted that it refers to work carried out well before the extraordinary assessment procedures were put in place for 2020 as a consequence of the cancellation of exams due to the coronavirus pandemic, but findings are nonetheless relevant both in terms of evaluating the previous reform and when considering the future of assessment in science in England.

Method

The questionnaire, developed by OCR and hosted on *SurveyMonkey*, addressed key issues around practical work that had been identified from the wider literature and OCR's rolling programme of teacher engagement. Participants were recruited via OCR social media and email, were informed of the purpose of the study and how their data would be used, and gave informed consent to participate.

As a reward for completing the survey, the participants were entered into a prize draw for a £100 voucher. In the first year, 619 people started the survey, with 235 in the second year and 199 in the third. Participants' results were not included if they made fewer than 20

responses to any questions after the second. This left 522 respondents in 2015, 191 in 2016 and 158 in 2017.

For analyses classified by subject and qualification (e.g. A-level biology), participants who stated that they taught that particular subject were included. For GCSE, a large proportion of participants taught both combined and separate science courses; limiting the analysis to those individuals who only taught individual subjects would have eliminated too many. The majority of those who answered the survey taught both GCSE and A-level. Most taught biology, chemistry or physics, though some taught more than one discipline.

Teachers from a range of different types of institution, which taught examinations provided by a variety of boards, participated in the questionnaire. Since not all categories are mutually exclusive, teachers were able to indicate that, for example, they taught in an academy with a comprehensive intake. There are multiple ways in which school type can be classified, in terms of intake, structure and level of education, making it difficult to provide a direct comparison with national figures.

Results

Purposes of practical science

An evaluation of the impact of the changes to the assessment of practical work should consider why teachers say practical work is important, in order to link the perceived purpose to the nature and type of practical work undertaken. Many formulated lists of proposed reasons for using practical work exist, which were summarised in Wilson, Wade and Evans (2016). These lists were the basis for the list of aims for practical work in this survey. Not all purposes are perceived by teachers to be of equal importance at each stage of learning and in each science subject.

The list of aims used in the Wilson, Wade and Evans (2016) study was:

- to develop manipulative skills and techniques;
- to develop reporting, presenting, data-analysis and discussion skills;
- to encourage accurate observation and description;
- to develop conceptual understanding;
- to experience the process of finding facts by investigation;
- to develop problem-solving skills;
- to experience scientific phenomena;
- to enhance motivation and develop confidence;
- to fit the requirements of practical examination regulations;
- to teach experimental design;
- to develop awareness of health and safety;
- to develop time-management skills;
- to develop teamworking skills.

Participants were asked to choose from this list the four most and the four least important reasons for conducting practical work at GCSE and A-level. Responses indicate considerable consistency in the reasons chosen across all three years.

At GCSE, the following purposes were the top four in all three years:

- to encourage accurate observation and description;
- to experience the process of finding facts by investigation;
- to develop reporting, presenting, data-analysis and discussion skills;
- to develop conceptual understanding.

Purposes seen as among the least important for GCSE in all three years include:

- to develop teamworking skills;
- to develop time-management skills;
- to fit the requirements of practical examination regulations.

That the last aim is seen as unimportant suggests that teachers are opposed to practical science being forced to fit regulatory requirements, rather than being used primarily to develop their students' skills and science knowledge. There is general consistency in the rank order of all purposes over all three years, despite major changes to the assessment of practical work over this period, which is also illustrative of the consistent understanding of the purposes of practical work shared among respondents to the survey.

At A-level, purposes 'to develop manipulative skills and techniques' and 'to develop reporting, presenting, data-analysis and discussion skills' are again ranked in the top four in all three years. These skills are among those specifically defined in the Common Practical Assessment Criteria of the A-level Practical Endorsement (Interboard Working Group for A Level Science Practicals, 2015). That teachers see these skills as among the most important purposes of the practical activities they teach suggests that the criteria are appropriately defined.

As well as 'to fit the requirements of practical examination regulations', the least important purposes in all three years include (among others) 'to develop teamworking skills' and 'to develop time-management skills'. These reasons also featured strongly in responses relating to GCSE practical activities. The limited emphasis on teamwork and time management may be indicative of a teacher focus on completing the course and concentrating preparation specifically on assessment requirements, rather than on wider skills for life and further study. This

is despite Holman (2017) identifying 'communication, teamwork and perseverance' as skills it would be desirable for practical work in science to support, alongside scientific enquiry, understanding theory through practical experience, specific skills and motivation.

There may also be a conflict with the demands of the A-level Practical Endorsement, which requires teachers to be confident of the competence of each individual student in each skill, apparatus and technique, leading to concerns about students working in groups larger than pairs. Pair or group working is reported to hinder the development of investigative skills (Davenport, 2014).

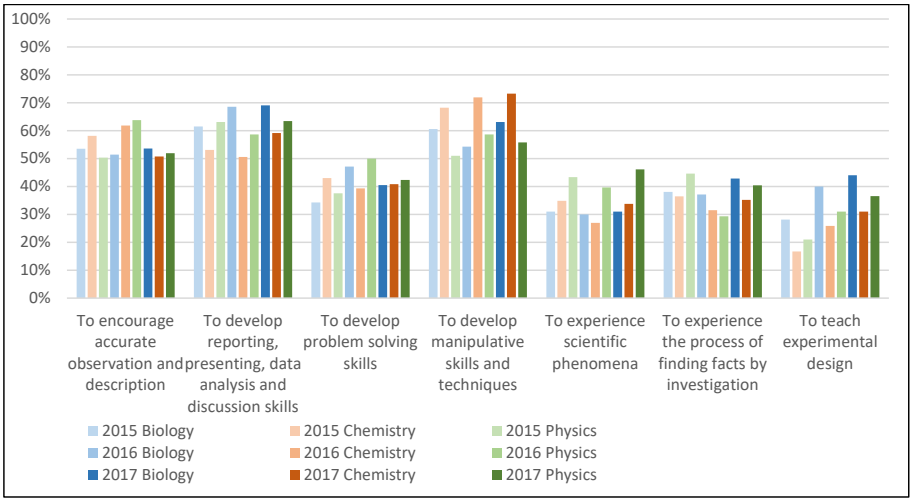

Figure 1 Selected responses to '*What are the most important purposes of practical work at A-level*', by year and subject

Purposes of practical work by subject at A-level

The same purposes are not necessarily common to all the sciences, which may have different requirements and approaches. Previously, manipulative skills and techniques were chosen as important purposes more frequently by chemistry teachers than physics and biology teachers, while the converse was true of reporting, presenting, data-analysis and discussion skills (Wilson, Wade and Evans, 2016). This is consistent with subject-specific lists of aims for practical work. Results from all three years of this survey confirm the finding: the percentage of respondents in the same subject, but different years, who highlight the same purpose is very consistent.

However, there are notable differences between subjects in relation to, for example, experiencing scientific phenomena (seen as more important in physics) and teaching of experimental design (more important in biology), as is evident from Figure 1.

It is likely that these differences reflect the nature of practical work across the three subjects. In physics, that much of what is investigated is linear relationships between two variables allows practical assignments to be investigative, often using variables such as force or temperature (Shayer and Adey, 1981). This is not the case at this level in chemistry, for example, where students may need to draw on their theoretical understanding of, say, atomic structure, to interpret complex, messy data appropriately, which may be a greater conceptual challenge (Wilson, Wade and Evans, 2016).

Extent to which models encourage the teaching of a wide range of practical activities

Teachers were asked whether they thought the assessment models in the courses they taught encouraged the teaching of a wide range of practical activities. At GCSE, only 24% believed this was the case in 2015. This rose little in 2016. However, in 2017, after the reforms, a clear rise (to 57% in agreement) was evident (Figure 2). Similarly, at A-level (Figure 3), the difference between 2016 (the first year after the reform at this level) and 2015 is clear. Nearly 80% of respondents in 2016 agreed that the models encouraged a wide range of practical work, and similar support was evident in 2017, whereas barely half of respondents agreed in 2015.

Although this finding is an indication only of teacher perceptions, and Cadwallader (2019) found that in most cases the students in post-reform cohorts had similar actual skillsets when entering higher education (compared with those who had studied pre-reform A-levels), it is clear that the new model is seen to encourage broader practical teaching. This point is worthy of note. Given this finding, and other work from Cramman

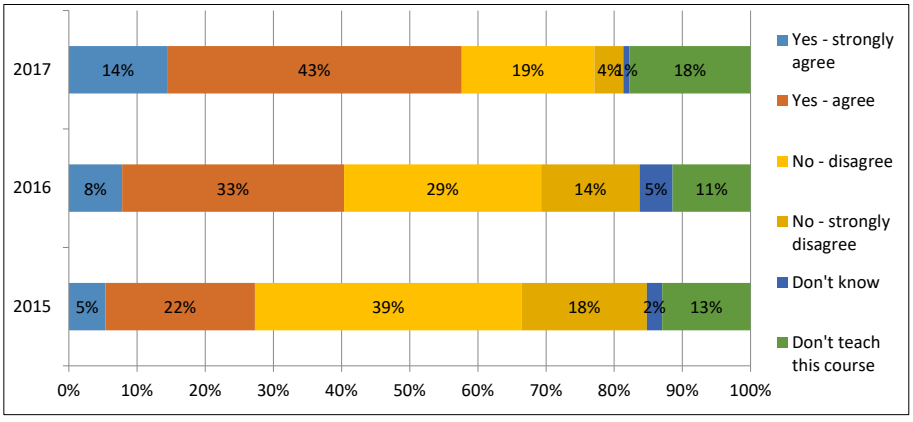

Figure 2 Responses to '*Do the assessment models used at GCSE encourage you to undertake a wide range of practical activities?*' by year

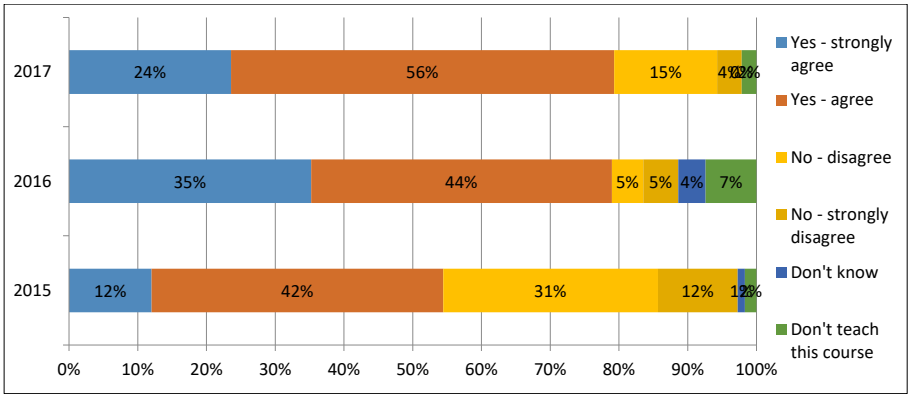

Figure 3 Responses to '*Do the assessment models used at A-level encourage you to undertake a wide range of practical activities?*' by year

Teaching time spent on student practical work and teacher demonstrations

One possible consequence of the reforms to assessment of practical work might be a change in the nature and quantity of practical activities undertaken. Particularly at GCSE, the previous arrangements for practical assessment were often considered to be time-consuming and to reduce the time available for students to undertake a wide range of practical assignments (Abrahams, Reiss and Sharpe, 2013). However, there appears to be little change in either the type (student-led or teacher demonstration) or quantity of time spent on practical work over these three years.

Practical activities are here classified into 'hands-on' student practical work and teacher demonstrations, which may serve different purposes. Taber (2015) suggests that teacher demonstrations may be more effective than

et al. (2019), it is clear that overall teacher satisfaction with practical science was considerably higher after the reforms.

Extent to which requirements have an impact on teaching and learning of theory

A clear change is evident in the years after the respective reforms towards practical assessment arrangements being seen to have a positive impact on the teaching and learning of theory. At GCSE, only 35% of respondents in 2015 believed arrangements then in place had a positive impact on students' ability to understand the relevant theory, and it was similar in 2016 (Figure 4). In 2017, this rose considerably, to 59%. At A-level, roughly half of respondents in 2015 saw the (old) arrangements as having a positive impact, but this again rose notably after reform, to 77% in 2016 and 74% in 2017 (Figure 5). This can be seen as an affirmation of the new model.

Previous assessment had been criticised for focusing too heavily on comparatively insignificant points, such as how to label the axes of graphs. The new system allows practical knowledge and theory to be assessed in exams, and manipulative skills to be assessed directly, and is praised by teachers for this. One teacher commented on being pleasantly surprised that this change had made teaching theory easier and allowed them to cover more material in the time.

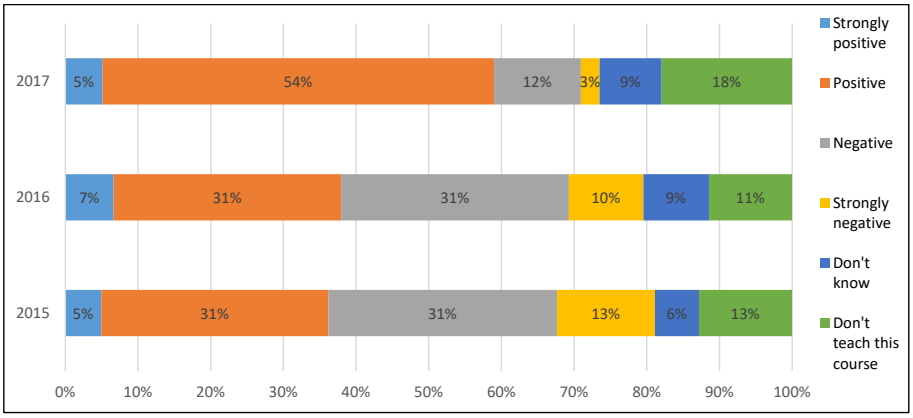

Figure 4 Responses to '*To what extent do current assessment arrangements for practical science have a positive or negative impact on the teaching and learning of theory at GCSE?*' by year

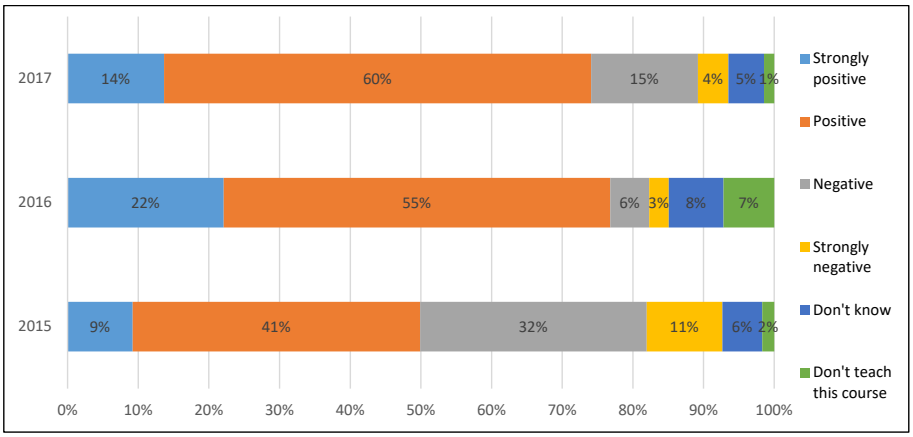

Figure 5 Responses to '*To what extent do current assessment arrangements for practical science have a positive or negative impact on the teaching and learning of theory at A-level?*' by year

student practical work at helping students to develop conceptual understanding, as students can focus on the phenomena they should be observing, without the additional demands of manipulating equipment. Teachers can focus on imparting the correct scientific knowledge, which may not be immediately apparent to all students, as they are not able to make the appropriate inferences between observations and scientific concepts. Teacher demonstrations may help students learn how to make accurate observations. If students conduct practical work without teacher guidance, they may struggle to interpret observations appropriately. (Note that the COVID-19-related extraordinary assessment requirements for GCSE science in 2021 include that students can cover required practical knowledge through teacher observation as well as direct experience.) There is a culture of students expecting there should be a 'correct answer' and for activities to be designed on that basis (Baker, 2015), and teacher demonstration may help to introduce the idea that a practical investigation is not necessarily a failure if it has not resulted in 'the right answer'. However, teacher demonstrations are not effective at enabling students to develop manipulative skills, as they are not required to handle equipment themselves. Student-led activities are more suitable for investigative work, as students or groups of students can carry out experiments they have planned themselves.

The majority of respondents in all three years say they spend more than 20% of teaching time on student practical work, at both GCSE and A-level. Roughly a quarter say they spend between 21% and 30% of this time on student practical activity in all three years: this is the most common response. There is a large range of responses, with roughly 5% of respondents saying they spend less than 10% of time on student practical work, but a slightly greater number spending more than 51% of time on this student practical work. At GCSE, over 70% of respondents say they spend less than 30% of lesson time on teacher demonstrations, while at A-level, the same percentage say they spend less than 20%. There is relative consistency over the years in each case.

Evidently, the time spent on each kind of practical work over the three years has changed little. This may be connected to the greater content of the new qualifications, which requires teachers to spend as much time as possible on teaching non-practical content. While reforms may not have given teachers any more time to do practical work, the fact that students are no longer required to perform time-consuming controlled assessment means that the time available can be utilised for more useful practical work.

Teachers will adapt their schemes of work and individual lessons as they become familiar with new content and assessment requirements. This relates to the 'sawtooth effect' (Ofqual, 2016), a phenomenon whereby cohort performance on an assessment is adversely affected when the assessment is reformed, followed by steadily improving performance over time as students and teachers gain familiarity with the new test's format and requirements. In science, teachers may have become more familiar with the flexibility of the Practical Activity Groups, which allow adaptation of activities and can be extended over two or more lessons.

Characteristics of practical science lessons

Domin (1999) classified practical activities into four categories: expository, inquiry, discovery and problem-based, differentiating practical work by three factors, which are outcome, approach and procedure. A practical investigation's outcome may be predetermined or undetermined. The approach may be deductive, in which students apply a previously learned principle, or inductive, in which students derive a general principle. Finally, the procedure to be followed may be given to the students or generated by students. Domin's categories were the basis for part of the survey, which asked teachers to specify what percentage of time spent on practical work was used (Wilson, Wade and Evans, 2016):

- for practical work that requires students to follow a specified procedure;
- for practical work that expects students to discover a concept or idea for themselves;
- on practical work that has a 'right' outcome.

A majority of survey respondents in each year say that their GCSE practical activities follow a specified procedure more than 80% of the time. Similarly, a majority in all three years say 80% or more of their GCSE practical assignments have a 'right' outcome, while less than 20% expect students to discover ideas or concepts for themselves. Practical work is described as slightly more investigative at A-level, as might be expected for these more advanced courses. Whether the limited emphasis on students discovering ideas for themselves matches the stated reasons for doing practical work could be questioned.

As is highlighted above, teachers see one of the major purposes of practical science as being for students to experience the process of finding facts by investigation. Many activities undertaken, it is implied here, do not lead to this. However, OCR practical activities are designed in an inherent hierarchy, with earlier activities scaffolded to develop fundamental skills, and investigative skills developed in later activities.

How practical results are written up

The reformed A-level Practical Endorsement requires students to keep a written contemporaneous record of

the practical work. A majority of respondents to the survey in both 2016 and 2017 say their A-level students write up their practical work in a lab book, but notable minorities continue to use A4 sheets or printed worksheets (Figures 6 and 7). At GCSE, the percentage for each option has changed little, with printed worksheets the most popular choice for write-up in all three years (Figure 7). This implies that courses are treated disparately by centres; GCSE students who might continue on to A-level are not necessarily being encouraged to write up their practical findings in an A-level-like way in order to prepare them for this requirement. While different curriculum stages have different approaches and focuses, Cort (2017) reports a potential lack of awareness in 11–16 schools of A-level requirements, and notes the benefits of signposting these to prepare students for possible further study.

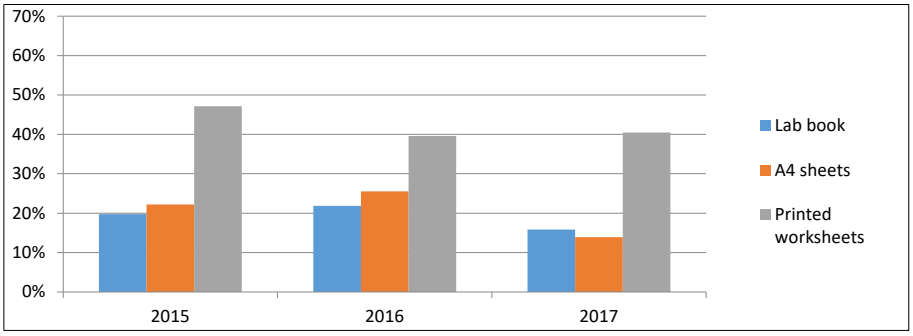

Figure 6 Responses to '*How do your students write up their practical work at GCSE?*' by year

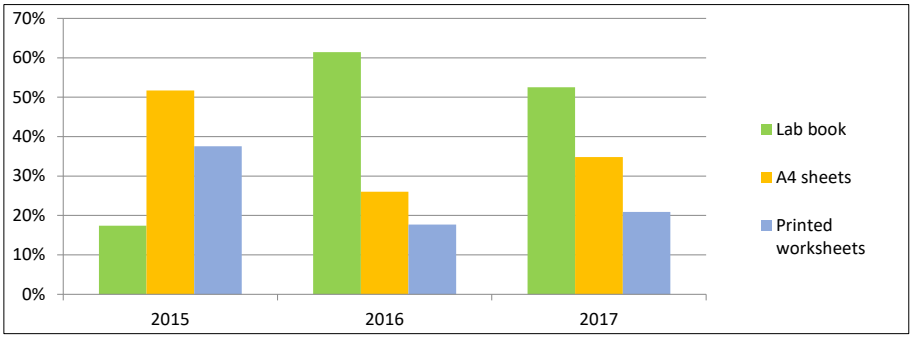

Figure 7 Responses to '*How do your students write up their practical work at A-level?*' by year

Challenges to effective practical science

From a list of possible challenges to conducting effective practical work, respondents were asked to choose any they had faced in providing their practical lessons.

In all three years, the following were considered to be challenges:

- lack of access to enough equipment;
- the need to cover curriculum content;
- the need to prepare students for written exams;
- the length of individual lessons;
- large class sizes.

Some of these challenges may be viewed as the consequences of national funding decisions and educational policies, and, other than the need to prepare students for written exams, which naturally remains a major focus for all GCSE and A-level science teachers, they are not really assessment issues, being more related to teaching and learning generally. More evidence that these are challenges to practical work is present in other reviews of the recent reform, particularly Cramman *et al.* (2019).

The need to undertake assessed practical work for the courses was seen as a challenge in 2015 by a large majority (69%). However, in 2016, only 46% described this as a challenge and the figure fell further in 2017 (to 40%). Given that assessed practical activities were no longer required at A-level in 2016, when the reformed qualifications were first assessed, or at GCSE in 2017, this can be attributed to the impact of the reform. It suggests teachers generally approve of the removal of controlled assessment in that the need to undertake such assessment is no longer seen as a challenge to the provision of effective practical work. Instead, practical time can be spent on tasks that deepen understanding and knowledge and improve skills.

It was not suggested in any of the three years that issues such as a lack of technician support, the time it takes to set up practical activities or health and safety requirements were a particular challenge to the provision of effective practical work. While issues around providing practical work for areas of science including genetics, astronomy and nuclear physics were highlighted, these were seen as inherent to the area of science rather than as anything attributable to the assessment approach.

Minor concerns around the administrative requirements of the A-level Practical Endorsement, and requests for greater provision of teaching resources, were highlighted, but these do not challenge the models of assessment. In 2015, pre-reform controlled assessment practical assignments, however, were criticised for favouring rote learning, having overly restrictive mark schemes, taking too much time and being open to abuse. Concerns expressed about the new courses are considerably more limited and specific.

Conclusion

On the whole, the reformed qualifications' focus on the indirect assessment of practical skills in examinations, and direct practical skills assessment in lesson time, generally finds favour with surveyed teachers. The new practical requirements are seen as an improvement on pre-reform approaches in that they encourage the teaching of a wide range of practical activities and have a positive impact on the teaching and learning of theory. Moreover, teachers no longer describe assessment protocols as a challenge to the provision of effective practical work.

While the new qualifications have had some impacts on the type and quantity of practical work offered to students, there is clear consistency across time about both what the purposes of practical work should be and the characteristics of the practical activities undertaken in lessons. This suggests the new qualifications have not caused radical changes to practical science provision in schools or its rationale, but have instead refocused on making practical lessons effective for teaching and learning and on making the assessment of practical work less obstructive and more useful.

These surveys did not cover other aspects of the reform, including the new courses' increased content and demand, though the work of Cramman *et al.* (2019) provides information on these themes. However, the results of the surveys are noteworthy in that they support the principle and implementation of the reformed approach to practical assessment, and will have an impact on exam board procedures and in the science teaching and assessment community more widely.

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