A-LEVEL

Biology, Chemistry and Physics

Practical Skills Endorsement – Cycle 2 2017-2019
Executive Summary

September 2019

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General comments

In order to be awarded a Pass endorsement of GCE science practical skills, a student must consistently and routinely meet the standard expected of each of the Common Practical Assessment Criteria (CPAC) by the end of the course. A student may demonstrate the CPAC in any practical activity undertaken during the course of study. Students may undertake practical activities in groups; however, the evidence generated by each student must demonstrate that they have independently met the criteria.

AQA first published mandatory Lead teacher training materials in September 2015. There are also a range of resources on the Teaching Resources webpage to support teachers in their planning, delivery, assessment and tracking of student progress. Resources have been evaluated and amended as appropriate since they were first published. More clarity has been provided in areas which teachers have requested support over the last four years; the AQA technician adviser continues to directly support teachers and technicians to manage required practical work delivery.

During Cycle 2 of the practical skills endorsement (September 2017 to June 2019), the four awarding organisations (AOs) worked together to monitor every school, college and tuition college who submitted A-level entries in Biology, Chemistry or Physics in June 2018 and/or June 2019. The monitoring team at AQA for Cycle 2 was made up of 125 current or recently retired science teachers, all with experience of delivering the reformed qualifications. The senior advice manager for practical sciences, Catherine Witter, was supported by eight team leaders to ensure quality in the monitoring outcomes and subsequent feedback to headteachers and principals.

Of the 1378 initial centre AQA monitoring visits that took place this cycle, 155 centres (11.2%) were unsuccessful requiring a second visit. Of those 155 centres, only 4 centres (0.29%) required a third visit before successfully meeting the required standard. Subject teams that required a second or third visit, having not met the standard expected initially, were supported directly by the senior team. There were about 40 informal consortium arrangements that operated between centres to enable A-level practical Science delivery. AQA also carried out 27 monitoring visits for international customers who made entries for reformed A-level sciences.

The extent of centre malpractice has continued to be much reduced compared with legacy specifications. However, there was a small number of schools, colleges and tuition centres during Cycle 2 that failed to offer the required practical work to students, treating practical work and theoretical work as mutually exclusive units. Students from those centres received a mandatory non-classified designation in summer 2018 and 2019 for their practical skills endorsement.

The cross board messaging in readiness for Cycle 3 (2019-2021) was published and communicated to all examination officers in September 2019. AQA Cycle 3 visits will be carried out during a timeline designed to support teachers.

During the previous monitoring cycles, AQA have gathered a great insight into how teachers are planning for the delivery of a minimum of 12 required practical activities and how they are tracking learner progress against the Common Practical Assessment Criteria (CPAC). Common strengths have been shared and pedagogy, that could undermine accurate assessment of CPAC, is highlighted.

Summary of findings

In general, the following strategies were reported by teachers to accelerate the progress that students made against the competencies and skills areas over time. Many of these were identified within Cycle 1 and have now become routine practice.

- Share the pass criteria for each CPAC with students prior to their assessment in practical lessons. Many teachers shared the mandatory lead teacher online training videos and clips with their students to exemplify what they needed to do to work at the required standard.
- Make a plan to determine the specific CPAC that will be assessed in each of the required practical activities and additional teacher-led practicals: this is key to ensuring that students can access assessment enough times to deem them as 'consistently and routinely' meeting the pass standard. AQA is committed to opening up practical work, not closing it down, so this is a task specific to each centre where individual teachers know their students.
- If appropriate, students should be able to discuss practical work as they carry it out to improve their understanding of the link between practical skill development and associated theory. Strict examination conditions are not expected.
- Students took photographs of their practical work, not only to support assessment but to remind them of what they did when they are revising from their lab book/practical folder for their examinations.
- Students tracked their own progress against the CPAC and engagement with ATs throughout the duration of the course, to allow them to set targets to improve weaker areas of their practical work.
- Peer assessment was thought to reinforce students' understanding of the pass criteria as they used a teacher-provided set of pass criteria that reflected the specific practical work being assessed.
- Most effective teacher feedback was non-onerous written feedback, strategically managing to raise awareness of what needed to improve.
- Written homework tasks were being used to assess areas of CPAC, particularly CPAC 2c, 3a, 5a and 5b.
- Consistent approaches are being adopted across all three sciences; the CPAC are generic competencies.
- Scheme of learning Year 7-11 strengthened to enable candidates faster access to making progress against the competencies.

Below is some feedback on each of the individual competencies. Please note that this feedback is identical to the end of Cycle 1, supporting a consistent approach being taken by teachers now that the practical endorsement is established.

Feedback on Individual Competencies

1. Follows written procedures

a. Correctly follows written instructions to carry out experimental techniques or procedures.

CPAC 1 was cited by teachers as being one of the more straightforward competencies to assess and many chose to offer this assessment opportunity to students in a number of their earlier practicals in the course. High numbers of teachers had provided a written set of instructions, most often the schedule in our Practical Handbook, and generated from that an additional teacher record document, a tick list approach, to capture evidence of pass criteria being met as the students worked. This may have included teachers' emboldening sections of the method text, making it obvious to then observe if a student had indeed carried out that action correctly, in the order written. This was often then strengthened by teachers verbally asking questions to individual students as they carried out their practical work, to ensure they understood the reason for each step. If time was limited, teachers often generated written questions (or used linked legacy specification controlled assessment questions) to test this understanding, which were offered as a homework task or as part of a test. If appropriate (and manageable), students had been encouraged to plan an experiment or investigation before being assessed against CPAC 1, the parallel assessment of CPAC 1 and CPAC 2 being seen often with Year 13 students.

Teachers have been mindful of maintaining strong quality assurance of assessment judgements; those delivering practical work in colleges with very large cohorts have found the additional teacher record form provided by AQA very reassuring, despite it not being a requirement. Assessment criteria chosen for observation have been previously discussed in a departmental meeting and all teachers assess all students against the same criteria using the same written method steps. Many teachers with class sizes in excess of 10 candidates have only assessed half the class, or paired up students and assessed one of the pair in any one practical to ensure that assessment is robust, although it may then be difficult to develop the required competency for all students if only the 12 minimum required practical activities are delivered.

Students made slower progress in CPAC 1 when pedagogy was not well developed or when they were not being as closely observed as they worked, with teachers just assuming that they were following instructions correctly based on the accuracy of the data recorded. Although this is a source of evidence for CPAC 1 pass, it should not be the only source as interacting with students will support the development of students' use of apparatus and techniques (ATs). Providing written method steps to candidates that are not of level 3 challenge, if offering additional practicals, or preferring to use other resources in preference to our Practical Handbook, were also unfortunately evident during monitoring. Some students also told us that they had already carried out a practical before repeating it for assessment purposes. Both approaches should be avoided.
CPAC 1 assessment is undermined if a teacher demonstration is carried out in the same lesson, as students simply copy the teacher's actions rather than engage with the written method steps independently, which is expected. Working in large groups, when it was difficult to assess each student's individual contribution to CPAC 1, was also considered unsatisfactory.

2. Applies investigative approaches and methods when using instruments and equipment

a. Correctly uses appropriate instrumentation, apparatus and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting.
b. Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and making adjustments when necessary.
c. Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled.
d. Selects appropriate equipment and measurement strategies in order to ensure suitably accurate results.

Although there is a real emphasis of a holistic judgement of progress against each CPAC, there is a need to ensure that students do meet the pass standard in all areas. Many students find investigative work difficult initially and teachers' early perception was that the planning for and delivery of CPAC 2 would be challenging. Some teachers left the first assessment of CPAC 2 until the second year of study, something that we would not recommend.

CPAC 2a and 2b involve the manipulation of apparatus, and direct observation of students working is required. Many students were demonstrating strong practice when their teachers interacted with them. Although multi-tasking was required in some of the more involved practical schedules, teachers expected students to work independently, which had the desired outcome. For example, a student might make adjustments to a method, or recognise that accuracy can be improved by introducing a further step or using a different piece of apparatus (perhaps evidenced by the student writing a note in a different colour against the method when working, which they go on to explain in more detail in their written work at a later date). Some teachers have introduced homework that challenges students to see the practical issues in the method steps written and to rewrite them before carrying them out in the next practical lesson (a strategy often also seen when encouraging students to consider CPAC 3). Some teachers would provide method steps that were 'thin' so that the students had to make choices and therefore adjustments.

There is no requirement for students to design and carry out a full investigation, however the majority of monitoring visit reports detail that the provision has been made towards the end of the course, to stretch students. Earlier on, CPAC 2c can be assessed in a number of different ways that require variables to be both identified and controlled. In a number of centres, students could be seen making notes in different colours in their lab books, aides-mémoires about things they needed to refer to later, and very often the different types of variables were reinforced in colour in students' work. Questioning students whilst they work to ensure that they could see the relationships between variables, and indeed understand the importance of controlling variables, was fairly common practice. Often CPAC 2d was assessed by requiring students to choose from a range of apparatus, then to justify choice of that apparatus with regard to uncertainties; this was seen in written tasks in addition to lesson observations.

Barriers to rapid CPAC 2 progress included a lack of choice of resources and teachers 'stepping in' too soon. Lack of technician support to model practical techniques to students was raised as a concern by teachers. It was also a concern in some centres that the meaning of key glossary terms were not always understood and applied, e.g. precise, accurate.

3. Safely uses a range of practical equipment and materials

a. Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field.
b. Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.

It was pleasing to see that many teachers required students to write a concise risk assessment detailing the main hazards, associated risks and control measures for all practical work taught.

Teachers who had a passion for practical work delivery had this as standard pedagogy. Although a written full risk assessment would be exceeding the pass standard for CPAC 3, it does no harm to model the requirements of higher education science courses. Many students could define the terms hazard, risk and control and discuss them during lesson observations. This, coupled with teacher observation of the non-negotiable, practical specific safety that teachers would expect to be employed through their own assessment of risk, meant that students in many centres were meeting the pass standard early on in the course.

In physics the assessment of CPAC 3 is more challenging due to the theoretical basis of the required practical work. However, teachers had identified the most appropriate practicals involving the use of lasers, springs and masses and radioactive sources and taken full advantage of those assessment opportunities at various points through the course.

If appropriate, teachers had provided a writing frame risk assessment document in the early practicals to scaffold students' access to the pass criteria. Many had adopted a 'tick list' additional teacher record, similar to that mentioned with regards to CPAC 1 above, to quality assure assessment judgements of CPAC 3 across teachers and all students.

In some cases, however, students questioned had never heard of or engaged with CLEAPSS 'Hazcards'. In addition to supporting the development of CPAC 3a this experience would be most valuable when referencing sources (CPAC 5b) and so advisers felt an opportunity was being missed. In some centres teachers told us that the pass standard was being met as "nothing went wrong" or "there were no accidents", which is not at all a reflection of the criteria being assessed.

Open questioning to allow the class to identify major hazards, associated risk and control measures before all students wrote them into their lab record clearly presented a barrier to the assessment of students working independently. In some centres, therefore, students conveyed little understanding of how to manage a practical incident at the time of monitoring, their lab records limited to basic low level statements including 'tie hair back, bags under stools' and so on.

4. Makes and records observations

a. Makes accurate observations relevant to the experimental or investigative procedure.
b. Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.

CPAC 4 was an early choice for assessment within practical work. Many students could design a basic table, complete with headings and units and record data on collection. They could identify the independent, dependent and control variables. CPAC 4a demanded both qualitative and quantitative data and biology teachers, in consideration of that, worked hard to up-skill students in their ability to draw a high quality biological drawing whilst introducing them to a range of different specimens. Photographic evidence was used to good effect in some centres, e.g. colour changes in titration experiments or transition metal chemistry. The need for accurate and relevant observations to be recorded was key to meet the pass standard in 4a, many students finding this sub-strand relatively straight forward, taking ‘accurate’ within the context of the teacher’s expectation of results given, within the limitations of their equipment.

When students understood the errors associated with the use of key apparatus and had had the opportunity to consider uncertainty calculations, they became more likely to plan for the collection of sufficient data and to record that data to the correct precision for the equipment being used, with less support. Reference to the expected value from secondary sources, an opportunity to assess CPAC 5, was fairly common. Again the use of glossary terms was a barrier in many cases initially. Copying out data tables neatly is not required and compromises the assessment judgement of CPAC 4, as data should be recorded on collection. If students insisted on doing this they learned to staple the original table into their lab record in addition.

In centres where CPAC 4 was considered weaker, students found it difficult to differentiate between decimal places and significant figures when recording data. There were also occasions were teachers had deemed work to be meeting the pass standard when there was a lack of sufficient data and repeats when expected.

5. Researches, references and reports

a. Uses appropriate software and/or tools to process data, carry out research and report findings.
b. Cites sources of information demonstrating that research has taken place, supporting planning and conclusions.

Students could take raw data collected for CPAC 4 and process it well, through calculation and graphical work. A calculator is a simple tool but in many cases well established links with universities enabled more sophisticated processing. In the strongest centres, processing data to formulate a conclusion was standard practice; many centres teach candidates how to use Excel to plot graphs to generate a gradient. It was exciting to see many students using their mobile phone as a tool, to take photographs of a field of view before a biological drawing, as evidence of qualitative change, to allow Rf analysis of a TLC plate or to support research to inform their practical work.

The majority of students were employing research to compare a number of possible methods or techniques, e.g. to produce aspirin. Students could consider factors such as cost, safety implications, yield, and accuracy of data, but also whether their school or college had the apparatus and if their lesson length was supportive of them choosing one particular method to carry out in the laboratory. Research was also well used to find secondary data to compare with recorded primary data, or to help to identify major hazards, associated risks and control measures (CPAC 3) associated with practical work. Much of this was a directed homework activity.

There is no requirement for students to write a full report; however sufficient evidence is required to enable assessment of the CPAC being focussed on, together with detail that may help students to answer an examination question related to the required practical. Some of the weaker practice seen was unsupportive of students maintaining a working lab record.

CPAC 5a, referencing to support planning and process conclusions was weak with some candidates not recognising what was required in a conclusion and evaluation. Progress against CPAC 5 was slowest when teachers had simply set a ‘find a method for’ task.

Preliminary research on practical work related examination questions

The AQA Science curriculum team have been working with the research arm of AQA, Research and Regulation, to understand how candidates are performing in questions that are practical work related and comparing that to performance on other questions that are assessing theoretical content of the specification only. When an examination paper is designed the Lead Assessment Writer tags questions, or parts of questions, that require students to have engaged with the Required Practicals within our specifications. Overall, at least 15% of the marks for all A-level Biology, Chemistry and Physics courses will require the assessment of practical skills. Those questions can be set in a practical context, where the question centres on the science, not the practical work. There can also be questions that require specific aspects of a practical procedure to be understood in order to answer a question about the underlying science. Questions directly on the required practical procedures can be written or questions that require students to apply the skills from the required practical procedures and the apparatus and techniques list can also be used.

Statistical analysis of how candidates performed on practical work related questions verses non practical work related questions indicates that high numbers of candidates are finding the indirect assessment of their practical work difficult.

To support schools and colleges further we are keen to understand the strategies that are being adopted by schools and colleges whose candidates do perform relatively strongly on practical work related examination questions. Telephone conversations were held during the Summer term of 2019 with teachers from centres that had secured a higher mean score for practical work related questions than that for non practical work related examination questions. The following points made were common to all centres contacted, and it should be noted that all had average to large sized cohorts.

All teachers spoken to stated that the science team had little staff turnover and that there was a lot of experience in-house eg teachers had been delivering science practicals for a number of years and/or had research experience through further degree qualifications or from a previous career in industry.
Technician support was deemed good and the budget awarded to the science team was adequate to support regular practical work delivery throughout the course. In 11-18 schools the Key Stage 3 curriculum in particular was skills based and during all of Key Stages 3, 4 and 5 students were encouraged to engage with extracurricular science that required practical work to be carried out. Teachers indicated that, on average, at least 30% of the curriculum time in science lessons was practical work based for students in all year groups.

Moving this research forward

We are now in the process of analysing the A-level Sciences examination data generated from the 2019 summer series to identify those centres that continue to perform above average on practical work related items. The vast majority of teachers have told us that the changes to practical work assessment for the current specifications has hugely increased student engagement with science and that they feel that they are preparing students for the next steps, whether it be to higher education or further training pathways. AQA is committed to ensuring that assessment is fair to all and, by sharing strategies through research findings, we hope teachers will continue to see practical science at the heart of science teaching.