Good Practical Science – making it happen

Writing a Policy

The Association for Science Education
Promoting Excellence in Science Teaching and Learning

Case Studies

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Writing a Policy

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The Gatsby Charitable Foundation supports education by strengthening science and engineering skills in the UK, by developing innovative programmes and informing national policy. The Foundation is committed to supporting practical science in schools and colleges. In 2017 Gatsby launched *Good Practical Science* by Sir John Holman. The report provides a framework for good practical science in schools. Using international visits, surveys and literature reviews, Gatsby developed a series of ten benchmarks for schools to use when planning their own approach to delivering practical science. ASE's *Making it happen* project focuses on the enabling of Benchmark 1.

The Association for Science Education (ASE) is the largest subject association in the UK. As the professional body for all those involved in science education from pre-school to higher education, the ASE provides a national network supported by a dedicated staff team. Members include teachers, technicians and advisers. The Association plays a significant role in promoting excellence in teaching and learning of science in schools and colleges.
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GATSBY

Introduction

This publication provides teachers, and others with an interest in science education, with accounts of how science departments in secondary schools have engaged in the process of formulating policy in one of the cornerstones of science teaching in British schools – practical science. The accounts have drawn on plans, diaries and descriptions of the issues faced by schools, the discussions undertaken and the construction of policy from agreed position statements.

Background

Gatsby's *Good Practical Science* set out an international standard of what world-class practical science looks like. It proposed ten benchmarks of what schools and teachers should do to achieve good practical science. Key to these is Benchmark 1 'Planned Practical Science' – the production of a written policy explaining why teachers use practical science, the expected outcomes and how those outcomes will be achieved. This benchmark is a strong enabler for achieving all 10 benchmarks and should serve as a prompt for science departments to discuss and improve their practice in line with these other benchmarks. ASE's *Making it happen* project supported Benchmark 1 by producing a series of resources for use by science departments to help them consider different aspects of writing a policy for good practical science. These case studies outline the processes used by a sample of schools that took part and the policies that they produced during the project.

Purposes

The case study accounts describe a range of different-sized schools, with different staffing, and from different regions of the country. They provide:

- descriptions of how schools addressed the constraints they faced in creating a consistent policy – including the lack of time available to them to discuss science teaching;
- a listing of the project resources that they selected to support their discussions; and
- their final written policies indicating the concerns and issues that became their focus.

The purpose of providing these case studies is to:

- stimulate reflection on current practice in teaching practical science and help identify some of the challenges experienced by learners;
- provide starting points for departments that may wish to work towards greater consistency and effectiveness in teaching practical science; and
- illustrate different ways in which subject leaders have overcome time constraints to help move their departments towards more consistent classroom thinking and behaviours.

Acknowledgements
Our thanks go to the science departments of the schools featured in the case studies:

- Elthorne Park High School, Ealing
- Helston Community College, Cornwall
- Scalby School, Scarborough
- Saint George Catholic College, Southampton
- Sir James Smith Community School, Camelford

Many other schools and teachers have contributed to this project through workshops, discussions and feedback. Their contributions are much appreciated.

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Case Study 1

Elthorne Park High School

Elthorne Park High School signed up to take part in the *Good Practical Science – Making it happen* project in summer 2018. Producing a written school policy on practical science is a key enabler for achieving a world class standard of practical science, as set out in the *Good Practical Science* report. By signing up, they committed to discussing, reviewing and improving their practice in line with the 10 Good Practical Science benchmarks.

Background

Elthorne Park High School is an 11-18 mixed school with around 1100 students based in West London. It has a sixth form of 200 students and offers a full range of A-level and applied courses. The school describes itself as research-driven. Staff are keen to engage with, and in, research to help to improve the educational outcomes for all students.

Starting points

Using a self-analysis activity on the introductory day course, planning how different activities should be presented and how practical science should progress were identified as two areas for development. The identification of different purposes for practical science was not considered a priority at this point (although, subsequently, this became a cornerstone of the written policy) and the school was fairly confident that their current practice takes good account of inclusion issues.

The process

The process was driven by the Head of Science, and involved discussions with the whole department, including the Head Technician.

The leadership team of the science department agreed in a project planning meeting which of the ASE resources to use in whole department discussions. The discussions resulted in the identification of the principles to be included in a written policy, which was then drafted by the Subject Leader. The draft was then reviewed and refined at further meetings.

Subsequently, it was decided that staff requisition sheets would be analysed to assess the frequency of practical science in lessons, and would be used in future to set staff appraisal targets.

Activities used

Faculty meeting 1 – The presentation from Module 2 'Purposes' was used to identify various reasons for using practical science, followed by discussion around the analysis of a specific practical activity (Module 2, Practical activity analysis, Task 2).

Faculty meeting 2 (a fortnight later) – The focus was Module 4 'Progression'. The most productive task was found to be an extension of the work carried out in the first faculty meeting, looking at a series of practical activities to consider how these lead to a progression in the skills of the students (Module 4, Practical activity analysis, Task 3). This allowed teachers to focus on a range of practicals that they were doing and think about why they were doing them.

Reflections

Following the development of the policy, the department has reviewed all the practical activities in the Key Stage 4 (ages 14-16) scheme of work. Lesson observations of Key Stage 3 (ages 11-14) practical science classes have been carried out and resulted in clear recommendations for improving practice. Involvement in the project has had a positive impact, which was noted in a recent Ofsted inspection, and has also contributed to the school receiving an award from SSAT for Professional Learning.

Acknowledgements

Thanks to all the teaching and technician staff at Elthorne Park High School science department for their enthusiastic participation, but particularly to Head of Science Peter Heffernan, Deputy Head of Science Andrew Rae, and science teacher Victoria Warren.

Appendix: Elthorne Park Practical Science Policy

Case Study 1: Appendix

Elthorne Park High School Practical Science Policy

At Elthorne Park High School (EPHS), the question most frequently asked of a science teacher is *'Are we doing a practical today?'* Students view science as a practical subject and, more importantly, enjoy and engage enthusiastically with the practical aspect of their science education. There is no greater motivational tool available to a science teacher than an expertly delivered practical lesson. With this in mind and following the guidance in the Gatsby report on practical science, and as a participant in ASE's project on policy writing to support the Gatsby report, the science faculty at EPHS has devised the following policy:

1. The aim of this policy is to lay down the guiding principles for the provision of world-class practical science.
2. The EPHS science faculty aspires to do as much meaningful practical work as possible.
3. All students are entitled to equality of provision in practical work. Practical lessons should be modified as necessary to be accessible to students of all abilities and those with special educational needs.
4. Each practical must have a clear teaching purpose. 'Teaching purpose' is defined as what the teacher wants the students to learn in that lesson.
5. 'Teaching purpose' can be the same or may be different from the 'lesson aim'. For example, in a lesson on learning to use a microscope, the teaching purpose and lesson aim are the same: 'To develop microscopy skills'. However, in a lesson on food tests, the lesson aim may be 'To test different foods for protein and starch', but the teaching purpose could be to evaluate the validity of the results and develop evaluation skills.
6. We have built our policy for school practical science on five main purposes:
    - To develop scientific enquiry
    - To develop knowledge and understanding of scientific concepts
    - To develop practical competencies
    - To develop teamwork and collaborative skills
    - To excite and inspire.
7. As well as traditional lab-based studies, practical work includes demonstrations, use of digital technology and is an integral part of field and project work.
8. In order to evaluate the extent to which the policy is being implemented and to ensure high quality of provision to all students, practical work will feature in the science quality assurance calendar every academic year.

9. At all Key Stages, a set of practicals guided by the five purposes will be developed and incorporated into schemes of work. The development will be informed by the collaboration of EPHS science staff, feedback from quality assurance, current research in the area of practical science and the school's research priorities.
10. The format for the set of practicals at each Key Stage is as follows:

Title of practical method(s)	Suggested teaching purposes	Delivery method(s)	Link to
V-I characteristic of a resistor	To develop practical competencies (use an ammeter and voltmeter)	Whole class practical	
The motor effect	To develop knowledge and understanding of scientific concepts (the motor effect and Fleming's Left Hand Rule)	Demonstration	

11. At Key Stage 3, the practical component should:
    - Develop the five purposes in a balanced manner
    - Prepare students for the practical demands of Key Stage 4 and in particular the core practicals
    - Introduce students to the vocabulary of practical science.
12. At Key Stage 4, the practical component should:
    - Further develop competence in the five purposes in a balanced manner
    - Enable students to achieve their full potential in core practical lessons and confidently answer examination questions related to practical work
    - Provide students with practical competencies needed to begin A-level science courses
    - Reinforce and extend the vocabulary of practical science and develop communication-friendly techniques that promote the excitement and appeal of practical science.
13. At Key Stage 5 (ages 16-19), the practical component should:
    - Be developed separately in each of the three disciplines of biology, chemistry and physics
    - Enable students to achieve well in core practical lessons and confidently answer examination questions related to practical work
    - Have experience of sufficiently complex practical lessons that prepare students for degree level study in the sciences.
14. The development of expert teachers and technicians is crucial to the successful delivery of practical science and, to this end, the science faculty will seek to provide or source professional development opportunities for all science staff.

Case Study 2
Helston Community College

Helston Community College signed up to take part in the *Good Practical Science – Making it happen* project in summer 2018. Producing a written school policy on practical science is a key enabler for achieving a world class standard of practical science, as set out in the *Good Practical Science* report. By signing up, they committed to discussing, reviewing and improving their practice in line with the 10 Good Practical Science benchmarks.

Background
Helston Community College is a co-educational foundation secondary school and sixth form located in Helston, Cornwall. The College's ethos and work are underpinned by the co-operative values of: self-help, self-responsibility, equity, equality, democracy and solidarity; and the co-operative ethical principles of: honesty, openness, social responsibility and caring for others. The College has approximately 1400 students on roll.

Starting points
The immediate effect of recent changes to the ways that practical work is assessed at GCSE has meant that teachers fixate on practical techniques as prescribed by the exam board. The Subject Leader considers that the department needs to change its approach and place more structure into practical science, and to have clear objectives whilst also providing opportunity for full investigative work, involving questioning with curiosity: *'At Helston College we believe that the most effective approach to teaching is through practically-based investigations'* (Helston Community College Practical Science Policy).

When this project started, practical work already pervaded the majority of lessons. Good guidance for teachers existed within schemes of work and it was thought that staff were clear about the purposes of practical provision. The aims of involvement with the project were to develop a written policy, which would help to develop clarity of vision and a more consistent approach within the team. As part of this process, the department wished to improve provision for all students, but particularly those who either had specific learning needs or were low attainers in science.

The process
Resources were chosen from those provided by the project that allowed the entire science team to take part, get involved and be heard. The challenges were mostly

logistical, with a shortage of time available for meeting together. Whole school pressures and finding time to support and develop less experienced staff were competing with time available for discussion and thinking. It was anticipated that colleagues would be resistant to the idea of change because of these pressures, but the resources were effective in breaking down any potential barriers and helped the team to sort their priorities. The activities allowed thinking to develop on how a practical policy could overcome the friction and tensions between preparing students for examination versus a 'curious investigative' approach.

Activities used

Module 7 'Producing a Policy' – The ranking and card sort exercises (Tasks 1 and 2) were effective in changing the departmental meeting into a whole team exercise that encouraged all key investors of the project to contribute.
Module 2 'Purposes' – This helped to rekindle the true purpose of science practicals and began the debate on the friction between a very narrow and prescribed delivery method and an open, more curious approach to science. The graphic around effective practice forms part of the policy.
Modules 3 'Planning' and 4 'Progression' – A number of resources were used that fitted in well with the way in which the team was thinking, and Module 4, Practical activity analysis, Task 3 was found to be particularly useful.

Reflections

The policy has meant that the department reconsidered their approach to practical work at an appropriate time in terms of their curriculum development work, and that they have changed their approach to practical science. There has been a strengthening of the objective lead approach and this has stimulated the team to provide more opportunities for extended practical work, and to promote a sense of curiosity amongst students. It has resulted in Subject Leaders now reviewing schemes of work from a practical science perspective.

It is noteworthy that the resources used stimulated further debate around what makes practical science effective in helping students learn science, and that their written policy now contains significant detail on the purposes and effectiveness of practical science teaching, as well as provision for SEND students. This science department, along with other schools featured in these case studies, has spent a considerable amount of energy in establishing a clear understanding of the purposes of practical science, as a cornerstone of their written policies.

Acknowledgements

Thanks to the science department at Helston Community College, led by Mr. Jon Hitchcock.

Appendix: Helston Community College Practical Science Policy

Case Study 2: Appendix

Helston Community College Practical Science Policy

Photographs have been removed from this copy of the Helston Community College Practical Science Policy for copyright reasons.

Aims of our provision

1. **Honesty: We are honest about what we do and the way we do it.**
2. **Science at Helston Community College:** We believe that a broad and balanced science education is the entitlement of all children, regardless of ethnic origin, gender, class, aptitude or disability. Our aims in teaching science include:
   - Preparing our children for life in an increasingly scientific and technological world. **Caring for others – we look out for and look after others.**
   - Fostering concern about, and active care for, our environment. **Social responsibility – in that we take responsibility for our communities and the wider world.**
   - Developing our children's understanding of the international and collaborative nature of science. **Solidarity – we work together to benefit each other and stand together.**
   - The value of fairness and a fair test. **Equity – we are fair and unbiased. Equality – we are of equal importance and have the right to be treated with respect.**
   - Science is the study of knowledge built from enquiry of scientific ideas that are tested through experiment and practical work. Our aim at Helston Community College is to foster and develop a student's curiosity and their own ideas so that they will be able to rationalise and question further the world in which they live. The body of knowledge that has already been developed by science should be used to consolidate understanding of science, along with practical experimentation, reliable method and application of skills in processing. Where possible, a practical approach to science investigative study should be used. This promotes **Self-help – we help people to help themselves,** and **Self-responsibility – we help students to take responsibility and answer for our actions.**

Functionality

This in turn should help our students to cope with the practical questions within their written papers and support them in their completion of the required practicals on their GCSE and A-level science courses. The students must complete a lab book at Key Stage 4 (ages 14-16) and Key Stage 5 (ages 16-19) to support their study, to document the practical competencies methodically and continuously. This will also allow the teacher the opportunity to monitor the progress of each student in a convenient and efficient way and to interject meaningful and purposeful questioning, both formatively and summatively. This lab book will:

- Give students the information they need to plan, prepare and perform required practicals; including the method, apparatus needed, common mistakes, misconceptions and safety. **Self-responsibility – we help students take responsibility and answer for our actions.**
- Provide one place to record the outcomes of their practicals, providing an easy reference for reflection and re-investigation. **Self-help – we help people to help themselves.**
- Facilitate challenge for the students with extra questions provided by the teacher that are designed to improve analysis, evaluation and maths skills.
- Prepare students for their examinations, with exam-style questions directly linked to the required practicals and apparatus use.
- The lab books will include scaffolding where appropriate to support the learner to engage with practical activity.
- Integrate AFL principles to practical work.

The required practical activities listed in the GCSE & A-level science specifications have been written to ensure that students have the opportunity to experience all the Apparatus and Techniques (AT) criteria required by Ofqual. In the exam board guides, there are *suggested* methods for carrying out the required practical activities to give ideas and guidance to help plan the best experience for students. It is important that the students carry out a sufficient variety of practical work to give them the opportunity to experience all aspects of the AT criteria required by Ofqual. The methods that have been suggested by the exam board will enable the students to do this, but it is important that teachers adapt practicals to fit the needs of the students using the resources available. Students *must* be given the opportunity to experience all the combined science AT criteria during their GCSE science course. Individual practical activities will not necessarily cover all aspects of an AT statement, i.e. it is only by doing all the required practical activities that all aspects of each AT statement will be covered.

Curiosity

Social responsibility – in that we take responsibility for our communities and the wider world. Solidarity – we work together to benefit each other and stand together.

At Helston Community College, we believe that the most effective approach to teaching is through practically-based investigations. Pupils experience the scientific phenomena for themselves and then use this experience to raise their own questions, thereby maintaining **curiosity.** In best practice, students can explain the purpose of their enquiry and the learning objectives involved. Lessons that allow students to develop a ‘learning journey’ should be developed, particularly in Years 7 and 8 (ages 12 and 13). Effective teaching will include constructed lessons that connect explicitly with other subject areas, notably mathematics, allowing students to relate their learning across subjects, and to use science as the context for others.

Interest in science should be stimulated by teachers' regular references to science in the media. The department will invest in a media board that will be maintained to show some of the latest developments in science and industry. Additionally, links to science news and careers will be explicitly taught in lessons to raise interest and awareness. STEM enrichment and engagement in activities for students and their families are supported by the science team. We believe that activities (not constrained by curriculum requirement) involving investigative science, from hypothesis to conclusion, should be made available. This will be done through enrichment, practical activities, STEM-based competitions and challenges. An additional dimension to this is the promotion of STEM careers within lessons. It is hoped that this will improve understanding, motivation and enthusiasm for science and the world around us.

Effective practical provision

Democracy – we have an equal voice and right to be heard.

It is extremely difficult to quantify the proportion of practical-based work that a student must experience to become an effective practitioner of science. However, annually, each Subject Leader and the Key Stage Co-ordinators will lead their team to justify and allocate practical opportunity in each scheme of work.

Purposes of practical work	**Activity analysis table (after Miller)**													
	A. By doing this activity, students should develop their understanding of the scientific approach to enquiry					**B. By doing this activity, students should develop their knowledge and understanding of the natural world**					**C. By doing this activity, students should learn how to use a piece of equipment or follow a practical procedure**			
Intended learning outcomes														
Students engage with specific aspect														
Students successfully complete activity														
Students link results to learning intentions														
What is the evidence of student learning?														

This row shows a continuum of direction given regarding the procedure that students used (how open/closed?)			**Tick one box to indicate a best fit**						
Students followed a given procedure		Students were given a question to frame the investigation and also detailed instructions on procedure		Question given and outline guidance on procedure; some choices left to students		Question given but students choose how to proceed		Students decide the question and how to proceed	

This will differ depending upon the Key Stage, subject, unit taught and class involved. When developing the practical work, the following key principles must be adhered to:

- Identify the scientific knowledge needed to conduct the practical with coherence and clarity.
- Identify opportunities for students to work collaboratively.
  Solidarity – we work together to benefit each other and stand together.

Using the practical is effective. Using a copy of the template above, identify the key learning outcomes in the practical activity being run. Using the following activity analysis has proved useful (the learning outcome may be multi-faceted or a focus on a single objective; regardless of this primary focus, flexibility should be written into the scheme of work):

- Ensure that the practical is 'effective'
- Identify the level of procedural and conceptual challenge in the practical. Write advice to ensure an adaptive approach to delivery. Different Key Stages and student groups may benefit from a change in 'scaffolding' to support learning or in creating greater autonomy and challenge.

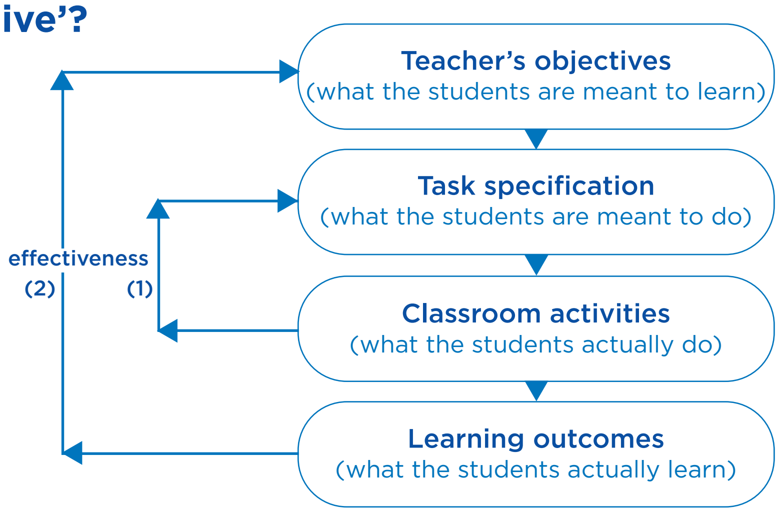
We must measure the effectiveness of our teaching through practicals by a comparison of learning outcome with the original teaching objective. Effectiveness can be 'tested' using formative and summative assessment. It is the responsibility of Subject Leaders and their teams to prepare additional questions and challenge to confirm beyond the kinaesthetic of the practical itself. The students must understand the purpose of the practical equipment and how it is linked to the reliability of the experiment.

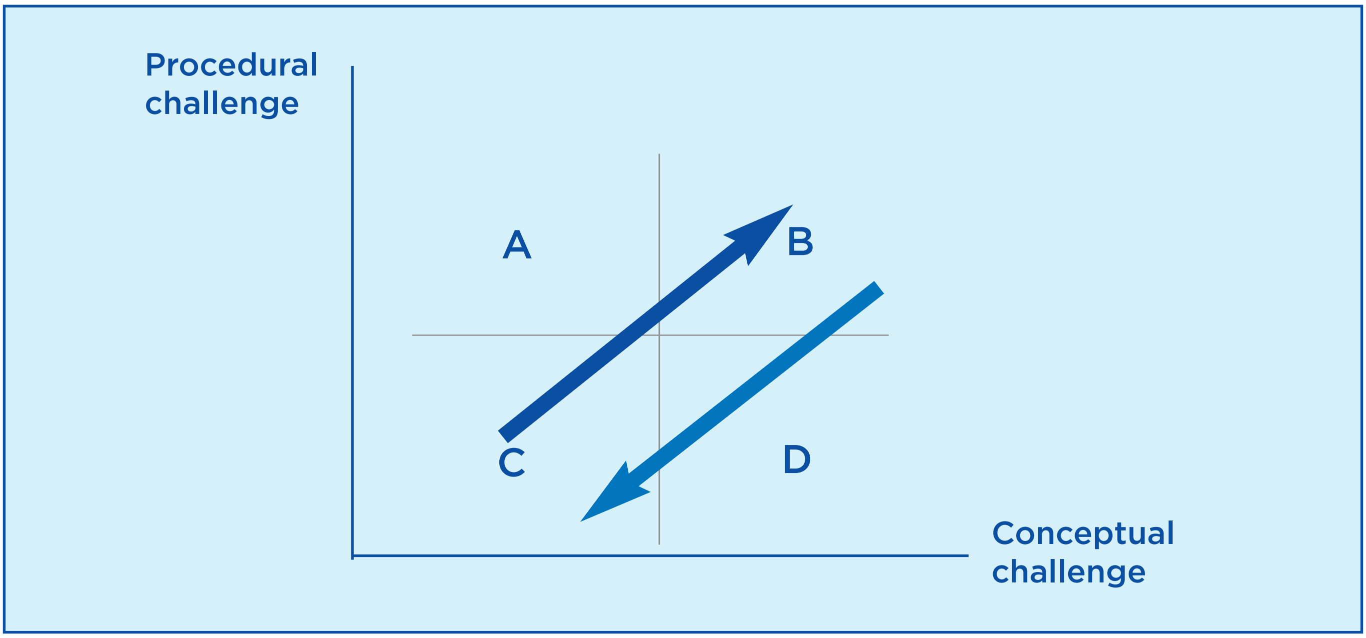
They must be able to link theoretical knowledge and scientific principle to the variables and answer examination questions associated with the practical.

- Allow and account for adaption and differentiation with the practical work. For example, in the preparation of salts, it is noted that the work conducted is applicable to many reactions and different salts.

What do we mean by 'effective'?

To say anything is 'effective', we have to have some objective in mind.





- Identify key questions that are able to test the students' understanding.
  Openness – we admit when we are challenged and when we are strong.
  - Verbal questioning.
  - Peer and self-assessment.
  - Formative questioning and Dedicated Improvement Time (DIT).
  - Summative assessment.

- Identify key terms and vocabulary. Link the practical to the knowledge organiser in the lesson sequence.

Inclusion for students' SEND and EAL

Caring for others – we look out for and look after others.

Science is taught within the guidelines of the school's equal-opportunities policy and with reference to the following document: G77 Science for Secondary-aged Pupils with Special Educational Needs and Disability (SEND), October 2018.

- We ensure that all our students have the opportunity to gain science knowledge and understanding regardless of gender, race and class, physical or intellectual ability.
- Our expectations do not limit pupil achievement, and assessment does not involve cultural, social, and linguistic or gender bias.
- We aim to teach science in a broad global and historical context, using the widest possible perspective and including the contributions of people of many different backgrounds.
- We draw examples from other cultures, recognising that simple technology may be superior to complex solutions.
- We value science as a vehicle for the development of language skills, and we encourage our children to talk constructively about their science experiences.

- In our teaching, science is closely linked with literacy and mathematics.
- We recognise the particular importance of first-hand experience for motivating children with learning difficulties.
- We recognise that science may strongly engage our gifted and talented children, and we aim to challenge and extend them through ‘curiosity’ questions and in extension tasks.
- We exploit science’s special contribution to children’s developing creativity; we develop this by asking and encouraging challenging questions and encouraging original thinking.

Exemplary practice

(Link to curriculum development, required practical).

The science faculty will strive to improve the delivery of practical science. This can be achieved by staff Inclusion and principles of support. Types of support needed for colleagues, for example NQT and subject specialism:

- Ensuring that there is a clear and well-planned practical structure. The Subject Leader and Key Stage Co-ordinators will lead their team to justify and allocate practical opportunity in each scheme of work. This will differ depending upon the Key Stage, subject, unit taught and class involved. It might be appropriate to develop understanding through computer simulation, demonstration or through development of a single facet of the practical and related theoretical knowledge.
- Conveyance of expert knowledge and skills. Faculty workshops and additional training used to develop skills in the delivery of practical within their subject specialisms. This is particularly important with the identification of key ideas and misconceptions within the practical and to help build confidence in teachers working outside their first subject specialism.
- Expert technical support is critical in ensuring that there is excellent provision from day to day. The Lead Technician will ensure that practical work in the laboratory is supported within the constraints of the science budget.

Each teacher and technician is responsible for ensuring safe practice in the delivery of science practicals and demonstrations. The procedures and guidance surrounding this very important area are significant, and can be found within the science health and safety policy, and associated documentation.

Case Study 3

Scalby School

Scalby School signed up to take part in the *Good Practical Science – Making it happen* project in summer 2018. Producing a written school policy on practical science is a key enabler for achieving a world class standard of practical science, as set out in the *Good Practical Science* report. By signing up, they committed to discussing, reviewing and improving their practice in line with the 10 Good Practical Science benchmarks.

Background

Scalby School is an 11-16 comprehensive school in North Yorkshire with about 1000 pupils on roll. *'The approach to improving the quality of teaching is very effective. It is rooted in the sharing of good practice, in a culture of sharing and openness. Staff welcome this coaching approach because it enables them to work together in a range of ways across the school'* (Ofsted report, March 2019).

The science department consists of seven experienced teachers. As a coastal school, there have been recruitment problems in the past. The change in demand of the new GCSE has been challenging for students and teachers, and staff absence in recent years has led to some teachers having to teach outside their subject discipline.

Starting points

'I am constantly reminded how little some students understand – even when you think they do, and how many of them are practised in producing right answers, but not really understanding the concept. I think this issue probably happens in practical work – right from when a student enters school. I really want to change that, and make sure students really understand the basic ideas then improve' (science teacher, Scalby School).

Two of the science team attended an introductory day, where they were asked to comment on their current provision and areas for development. It was striking that each, independently, gave very similar responses.

Aspects of current practice that are effective:

- Inclusion – the ability of less able students to carry out practical work
- Safety
- Engagement, so that in the long term students make good progress.

Aspects to be developed:

- The reasons for doing practical science
- Using practical activities to teach science concepts
- Skills in practical science.

Through involvement with this project, the development of a written policy was seen as an important step in creating a more consistent approach across the department and improving the quality of teaching and learning.

The process

Presentations used on the introductory day (part of the resources produced for the project) were edited and compiled into a single presentation used to introduce the project to the department. Through discussion, it was agreed that practical science would become a teaching and learning focus. A key aim was to establish the purposes of using practical science in teaching and for these to be made more explicit. Use was made of the EEF *Improving Science Teaching* document to support discussions. The Head of Science then produced a draft policy document, which became the focus of further discussions in subsequent meetings with the department, before being presented to the Senior Leadership Team link. There was only limited time available in departmental meetings for these discussions, and so science teachers were asked to review documents and presentations outside of meeting time.

The school has a reflective approach to teaching and learning, making small changes and then evaluating them. The practical science policy was deliberately kept brief, so that it is easier to discuss practical activities with colleagues and compare practice to policy. In this way, it is intended that teachers will gradually change their practice. Formal lesson observations are no longer carried out, but this project will provide a good opportunity for peer observation and incremental coaching.

Activities used

The areas covered in the initial departmental meeting were Module 3 'Planning', Module 4 'Progression' and Module 5 'Inclusion'.

In the introductory meeting attended by two members of the department, inclusion and progression were identified as aspects of practical science that were considered to be effective. It is interesting to note that, rather than tackle new aspects, further development and embedding of these existing strengths were considered worthwhile.

The department has plans to do further work on Module 6 'Support' in the following term.

Reflections

The department plans to arrange a meeting in the near future to reflect on changes to practice, and possibly introduce further aspects in their policy.

An example of a change in classroom practice that has arisen from the project is: *'When I teach a complex practical, I always give students a chance to practise using the equipment and generating some results in the lesson prior to the practical. Then I give them the opportunity to carry out the practical and look at the science that is happening. I don't always have the time – but in that case I can demo'* (recent comment from a science teacher at Scalby School).

The Subject Leader is expecting to see evidence of similar changes in other teachers' incremental coaching journals, although it is recognised that this process will take time to become embedded.

Acknowledgements

Thanks to the science department at Scalby School, led by Mr. Matt Docking.

Appendix: Scalby Science Practical Work Policy

Case Study 3: Appendix

Scalby Science Practical Work Policy

The vision

Practical work is an important part of science education. Scalby science teachers aim for students to:

- Develop an understanding of the scientific approach to enquiry
- Develop knowledge and understanding of the natural world
- Learn how to use laboratory equipment and how to carry out standard procedures

Progression

From Key Stage 2 to Key Stage 4 (ages 7-16), students need to experience an increasing level of demand and competence in enquiry skills, modelling or explaining ideas about the natural world, and use of laboratory equipment.

We get the basics right first and build on them, during the student's time in the school. When the basics are right, students' skills improve over time. Teachers use student experience and skills to plan for the right level of demand in practical work.

Inclusion

All our students have the right to experience practical work. We plan for the most effective way of doing this, thinking of the students' needs. Examples of this include SEND, disadvantaged students and the ability of students. Teachers plan how students can best access the core reasons for practical work.

Implementation

How do we change our day-to-day practice?

The reasons for practical work are a focus for teachers in incremental coaching. We discuss practical work as part of our culture.

Strategic Objective 1 for the school is to increase attainment in science to 65% grade 5 and above. Leaders focus on practical work as a way of supporting this.

Case Study 4

Sir James Smith's Community School

Sir James Smith's Community School signed up to take part in the *Good Practical Science – Making it happen* project in summer 2018. Producing a written school policy on practical science is a key enabler for achieving a world class standard of practical science, as set out in the *Good Practical Science* report. By signing up, they committed to discussing, reviewing and improving their practice in line with the 10 Good Practical Science benchmarks.

Background

This is a small secondary school in North Cornwall, with 550 students on roll. The science department consists of a small experienced team of teachers who have worked closely together in recent years to implement a number of different curriculum reforms.

Starting points

At the start of this project, the school was making effective use of practical science to motivate students through a series of practical activities already embedded in their Key Stage 3 and 4 (ages 11-16) curricula. Developing these activities so that they were more focused on teaching specific content, and the need to identify progression in skills throughout the Key Stages, were identified as areas for development. The school did not have a written policy for practical science at this stage and recognised that further planning on how practical activities should be presented and managed was required.

The process

The Head of Science attended an introductory session about the project, which outlined the various resources available in each of the seven modules. Following that meeting, a strategy was decided and an action plan created. The intended approach was to create starter policy statements and then agree as a science team how evidence could be collected to support or refine each of the statements.

The team were involved in learning walks and discussions to collect evidence of current practice. They also met for brief periods ('bitesize') each week and used these opportunities to select and engage with activities from the project resources. The focus during this development period was on Key Stage 4 GCSE required practicals and on Key Stage 3.

The draft policy statements were then discussed, refined and used to create a written policy. Material from the discussion activities were included in the policy appendix, with the intention that these could be revisited as the department monitored the impact of the policy and applied it to the full range of practical activities employed by the school. *'It's really refreshing to be thinking about the skills and the activity we are doing and challenging me to think what is its purpose'* (member of science team at SJS).

Activities used

- Each member of the team was provided with a copy of the Gatsby *Good Practical Science report* to read during the policy development period.
- Module 4 'Progression', Analysing practical activities, Task 3, to identify the skills associated with each of the required practicals in GCSE biology chemistry and physics.
- Module 2 'Purposes', Practical activity analysis, Task 2, to introduce different purposes for doing practical science.
- Module 2 'Purposes' task cards from the rocket building activity were used to create generic task cards, which, in turn, were used with students to make the purpose of each Key Stage 3 practical activity more explicit.
- Module 3 'Planning', Thinking about challenge, Task 4, to review Key Stage 4 practicals and decide if the current way of presenting these activities offered sufficient challenge for students.
- Module 3 'Planning', Thinking about challenge, Task 1. The Venn diagram exercise was adapted to review the ways in which practical science is presented for each year group.

Reflections

The development of a written policy for practical science at SJS is ongoing. The strategy adopted was to focus on GCSE practical activities and then consider how the Key Stage 3 curriculum lays effective foundations for later years. Further work is planned for this academic year on ensuring that the Key Stage 3 curriculum is reviewed and, where necessary, enhanced.

The department is continuing to collect evidence of the impact of new approaches, and to further consider as a team how their GCSE curriculum can maintain progression and challenge in practical science.

Acknowledgements

Thanks to Sir James Smith's Community School science department: Georgie Precious (Head of Department), Polly Day (chemistry), Andy Garner (physics) and Ed Kirk (biology /physics).

Appendix: Sir James Smith's Community School Science Practical Policy Statements

Case Study 4: Appendix

Sir James Smith's School Science Practical Science Policy Statements

Inclusion

1.1 All students have access to practical activities where appropriate and when the correct risk assessment is in place.

1.2 All barriers to accessing practical science will be considered on a case-by-case basis and may include:

- Physical impairment such as vision, hearing or mobility
- Behavioural issues
- Language issues.

This applies to all staff within the science department where applicable.

Solutions table

Barrier	Solution
Students with impaired vision doing microscopy	Using digital photography taken using the microscope so that they can view the slide on the big screen.
Students with ADHD doing extended practicals	Using TA attached to the science department if available. Student can be offered regular breaks and have access to a 'green card' (timeout). Consider practical pairings to ensure peers are suitable to work together.
Students with autism	Provide as many picture cards/stories to methodology. Ensure all equipment has picture cards associated with trays and trolleys.
Weak literacy and understanding	Differentiated instructions and pictures to support method.
Dyspraxia	Careful pairing to ensure peer support is effective. Where possible, provide plastic containers to avoid breakages.

1.3 All staff where appropriate will seek further support and guidance if access to practical work is compromised.

Resources available in school are the SEND department within school and experienced teachers within the department. Resources available externally are CLEAPSS, MAT teams and RNIB.

1.4 All staff will ensure that the students' learning environment is suitable for the needs of all students; that work space is uncluttered; that whiteboards are clear after each lesson and that no unnecessary paraphernalia is surrounding the board; that the date is always clearly written at the start of each day; and that the nature of the wall displays are appropriate and effective.

Support for staff

2.1 All staff who are working in the department will have an induction and a continued professional development (CPD) programme that they contribute towards.

This will:

- Ensure the provision of high quality lessons
- Provide professional development for individuals
- Develop the capacity of the team.

2.2 All staff will be supported to develop high quality provision for students in practical science:

- All lessons are taught with the maximum impact on progress and outcomes.
- All lessons are effective with regard to the understanding and delivery of concepts, processes and skills.
- All lessons are cost-effective in terms of time, resources and support required.

2.3 All staff will consider a set of guidelines when planning for practical activities from which they can then decide what activity is suitable:

- Assess your own (teacher) level of confidence when using the equipment and with regard to the content being delivered.
- Assess the class's ability to carry out activities whilst being safe.
- Assess the resources available and the accessibility to a site that may support the activity.

Progression – general

3.1 All staff to ensure all students' progress in the concepts of practical science.

3.2 All staff must understand how particular activities can support progression through the skills.

3.3 All staff must understand the pathway of progression through Key Stages 2, 3 and 4 (ages 7-16), knowing the differences in practical science between the different age groups.

3.4 All staff must be aware of which experiments explore which skills and which processes. Use the Module 4, Practical activity analysis, Task 3 to explore, map and identify gaps.

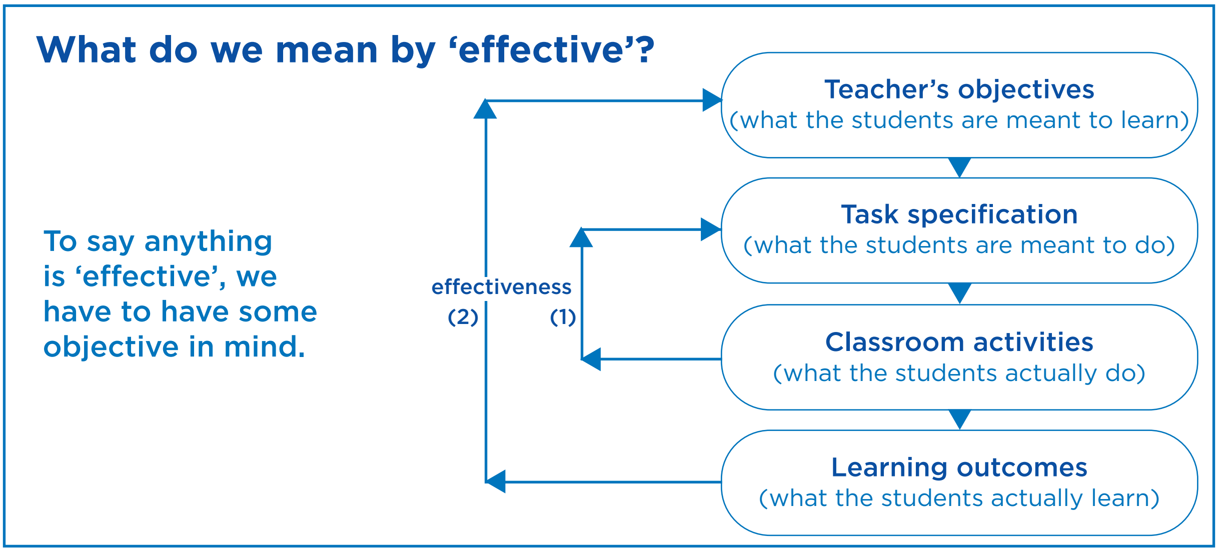
3.5 All new practicals must be analysed to identify the learning outcomes of the practical and to see how effective the activity is for achieving these. Use the Millar Activity analysis and diagram What do we mean by effective? to support this analysis.

3.6 All students are to be involved in assessing the purpose of a practical at Key Stage 4 where appropriate (required practicals). Use student speak task cards.

3.7 All staff should have a clear sense of how good students are at planning investigations. Use the 'Progression of Skills' appendices to inform your planning throughout the different Key Stages.

Supporting materials

- All activities are listed in a 'planning for practical science' Venn diagram – different types of activities (ref: Appendix 2.3 above). Not included in this Appendix.
- Practical activity analysis, Task 3 (ref: Appendix 3.4 above). See CPD materials.
- Use the Millar activity analysis and diagram What do we mean by effective? (ref.: Appendix 3.5 above):



- Use student speak task cards that have been adapted from the task cards used in the rocket building activity in Module 2 (ref: Appendix 3.6 above). Not included in this Appendix.

Progression of skills through Key Stages 3 and 4

- Year 7 (age 12)
  - Become confident and familiar with the use of specialist/new equipment – or equipment with better resolution.
  - Practise collecting and presenting data using a provided framework.
  - Identify hazards associated with given activities and suggest how to reduce the risk associated with those hazards.

- Year 8 (age 13)
  - Develop the skill of devising testable questions based on some scientific content.
  - Carry out your own planned activity to collect adequate data to address a question.
  - Revisit specialist equipment and use new pieces of equipment (with guidance) in a procedure that is not familiar.
  - Write a risk assessment using the framework below:

Hazard	Risk	Precaution

  - Present data in a given format and identify a pattern in those data.
  - Draw a simple conclusion based on the data collected or provided.

- Year 9 (age 14)
  - Revisit specialist equipment and use confidently following a familiar/unfamiliar procedure.
  - Successfully be able to recall observable features of activities and recall patterns in those observations.
  - Select a suitable way to present data to show patterns.
  - Select a suitable way to analyse data to show patterns.
  - Evaluate the evidence and conclusions drawn from that evidence/data/observations.
- Year 10 (age 15)
  - Translate data from one form to another and analyse.
  - Interpret data and present explanations.
  - Consider the management of risk and the ethical use of organisms.
  - Assess unfamiliar variables and suggest measurements that are of a greater precision than previously.

- Year 11 (age 16)
  - Use scientific theories and explanations to develop hypotheses (chemistry RP – temp change and rate of reactions).
  - Evaluate data and methods; propose improvements that are of a greater degree of precision or resolution.
  - Application of scientific knowledge rather than planning the experiment to gain a greater degree of understanding of the content and purpose of a given practical.

Further work

- Purposes of practical work 'Millar Analysis' individual teacher task will continue through until Easter to give a larger body of evidence to review the progression through Key Stage 3.
- Key Stage 3 practicals' tick sheet on approach to scientific enquiry and practical procedure needs to be completed.
- Additional practicals/activities in Key Stage 3 need to be completed to add to our support section and these then need to be added to the Venn diagram activity, partially to identify weaker areas amongst staff but also to make sure that temporary/new staff have guidance on how they may approach the list of practicals at this Key Stage.
- Task cards need to be piloted at Key Stages 3 and 4 – this is a more long-term change and should be discussed at length, because this is changing how we deliver practicals and our approach.
- CPD session on 'Thinking about challenge': this will draw our attention to those practicals/activities that are conceptual or procedural and therefore we may have to adjust where the statements appear, if we are doing said practicals in a different place. *We plan to do this for Key Stage 3 and JUST the required practicals at Key Stage 4 to start with. What we want to avoid is those that are low both conceptually and procedurally because we then have to ask the question 'why are we doing that activity?'.*

Case Study 5
St George Catholic College

St. George Catholic College accessed the resources and developed their policy throughout the autumn of 2018. Producing a written school policy on practical science is a key enabler for achieving a world class standard of practical science, as set out in the *Good Practical Science* report.

Background
St George Catholic College is a Catholic voluntary aided comprehensive school for 11-16 year-olds in Hampshire. It has 865 students on roll and became a mixed school in 2013. It is in the top 10% of schools nationally for pupil progress.

Starting points
The school was not part of the pilot cohort for this project and did not attend one of the introductory meetings about producing a written policy for practical science. The Head of Science had read the Gatsby report *Good Practical Science* and recognised that the school's current policy was more about health and safety issues and how to order equipment, rather than being about why practical science is used in teaching, what students learn by doing practical science, and how teachers can evaluate the quality of learning. The aim of creating a new policy was to provide support for staff in the department.

The process
A recurring pattern in schools that were successful in completing the production of a written policy for practical science was the involvement of members of the Senior Leadership Team. In this case, the Head of Science was line-managed by the Head of School, who already had a good understanding of science and was supportive of efforts to promote quality and consistency of teaching across the team. Using arguments about consistency of approach, and with a significant number of new staff, the department was able to secure additional meeting time to complete the project.

All members of the science department were involved in discussions and activities. However, in line with many other schools, the written policy was then produced by the Subject Leader, with input from one or two colleagues in the department before the final version was produced.

In addition to the formulation of a written policy, discussions led to the production of a planning tool for practical science that helped teachers focus on the level of challenge presented by each activity, and to identify the purpose of an activity when deciding how the activity should be carried out (individually, as a group or class demonstration).

Activities used

The project resource modules selected for departmental discussions were:

Module 1 'Introduction'
Module 2 'Purposes'
Module 5 'Inclusion'
Module 7 'Producing a policy'.

The activities that were considered to have most impact on departmental thinking were:

Module 2 'Purposes', Practical activity analysis, Task 2
Module 3 'Planning', Sorting exercise, Task 1
Module 7 'Producing a policy', Ranking statements, Task 2.

Reflections

The policy statement ranking exercise was carried out in smaller groups based on teaching experience. The newly qualified teachers expected different things from the policy compared to experienced members of the team and revealed the support they felt they needed. This suggests that the policy will need to be adapted each year as the experience of the staff develops and changes.

Practical science has been a focus of observations and learning walks as the policy has been developed and will continue to be a focus in the coming terms. This monitoring will be used to review support for teachers, coupled with evidence of emerging practice from department meetings, feedback from newly qualified staff and from technicians.

Acknowledgements

Thanks to the science department at St George Catholic College, led by Mr. Euan Douglas.

Appendix: St George Catholic College Practical Science Policy

Case Study 5: Appendix

St George Catholic College Practical Science Policy

Scope of policy

- This policy applies to all science teachers, technicians and members of the leadership team.
- This policy covers all science lessons, whether they take place in a specialist science laboratory or not.
- This policy does not cover the Health & Safety management and precautions taken within lessons.

Safety

The safety of students and staff is the first priority at all times. Consideration of what is safe comes before all other considerations (including cost and resourcing).

Purpose of practical science

The *Good Practical Science* (2017) report identified three main purposes for doing practical work in science lessons. These are:

- To develop an understanding of the scientific approach to enquiry
- To develop knowledge and understanding of the natural world
- To learn how to use laboratory equipment and how to carry out standard procedures.

It is acknowledged that each of these purposes can be met without carrying out practical work, and so it is down to the judgement of the teacher to decide when and how a practical activity is included within a lesson.

Responsibilities

- Senior Leadership Team: The SLT will understand the distinctive nature of science, and the value of practical activities. They will endeavour to provide suitable resourcing to allow students a good experience of practical science.
- Head of Department: As well as responsibility for monitoring Health and Safety across the department, the HoD will work to raise the profile of practical science across the department and College. The HoD will ensure that staff are suitably trained and supported to deliver high quality practical activities, and work alongside the technician and SLT to ensure that the resourcing is in place.

- Technicians: The technician team will provide the practical equipment requested by teachers, and maintain it as needed. They will ensure that supplies of consumables are kept up-to-date, that new staff are allowed time and space to practice practical activities. Where appropriate, they can support within lessons either through performing demonstrations or supporting the teacher as an experienced specialist.
- Teachers: All teachers in the department will make good use of practical activities as part of their teaching. They will consider carefully what the intended learning is from an activity, and plan how this is best achieved: for example, whether students should work individually, in groups or observe a demonstration. Teachers will be proactive in their CPD and engage with opportunities to develop and improve their practice.

Inclusion

All pupils should, where possible, be given access to all practical activities taking place within their lessons. Teachers will consider EAL and SEND students, and make adjustments where needed, without compromising safety. Support and advice will be sought by teachers from the Head of Department, technicians and SENCO where needed.

Level of technician support

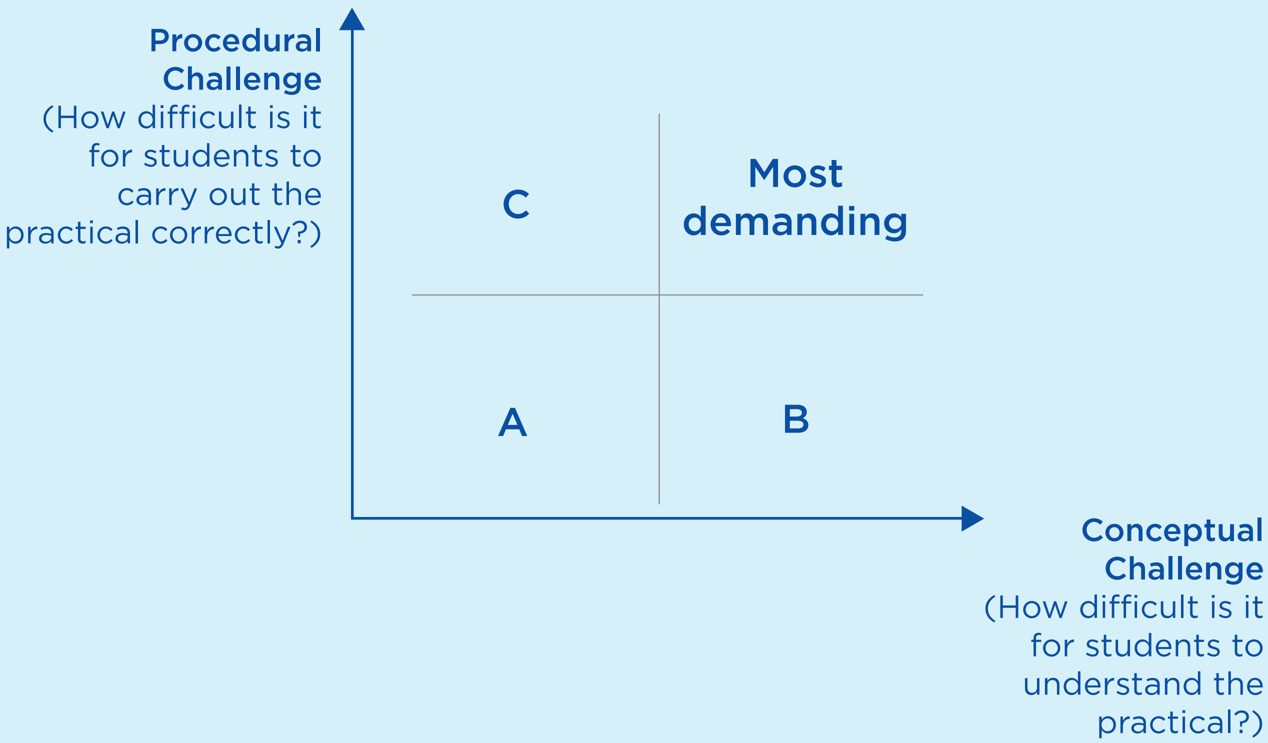
The Association for Science Education (ASE) has set a benchmark for technician support, which our school will aim to meet. The benchmark is:

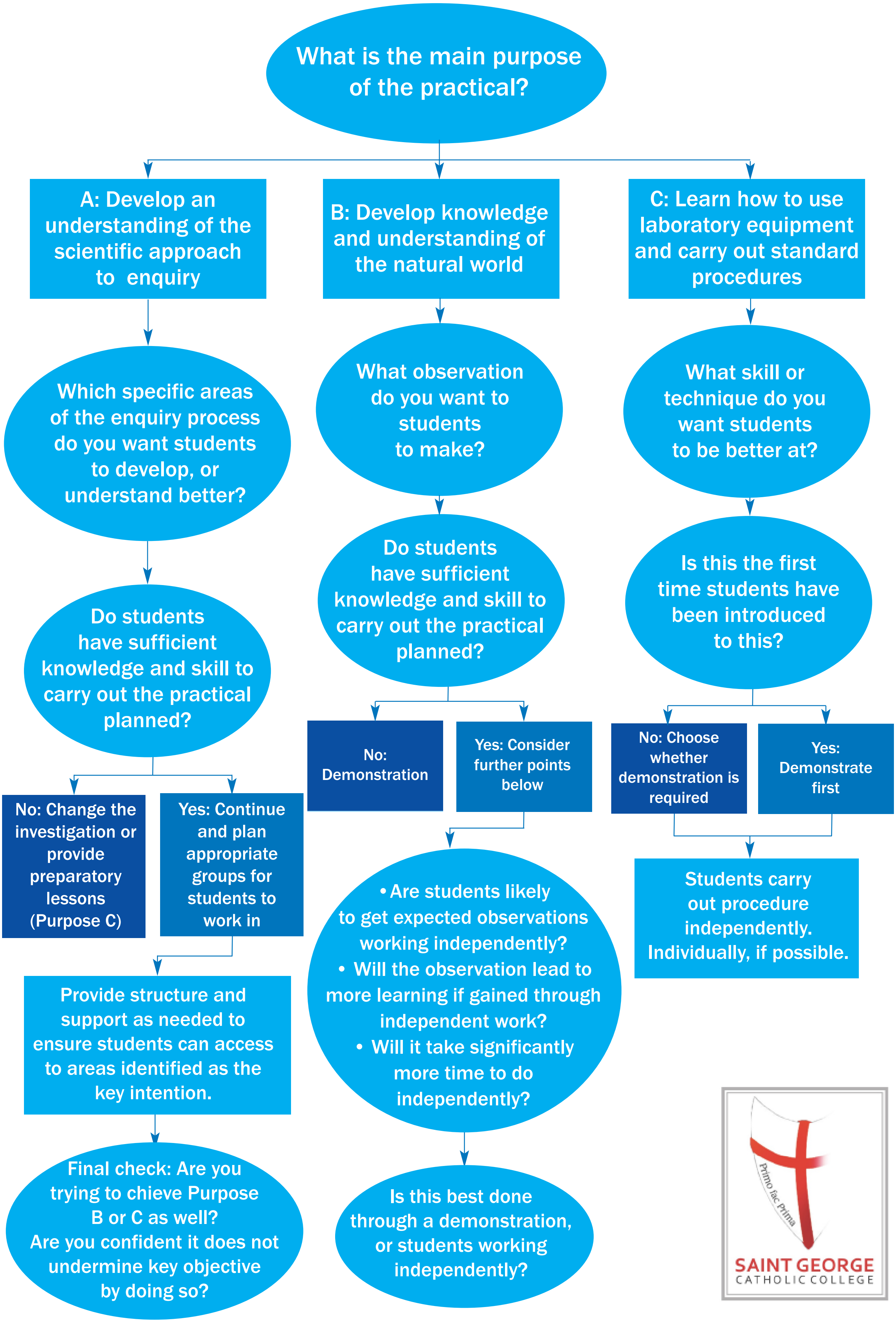
- Technician hours per week = total science teaching hours per week x 0.65. This calculation is based on technicians being employed 52 weeks per year. For the academic year 2018-19, this produces a benchmark target of 60 hours per week.

As laboratory teaching space is limited within the current buildings, it is accepted that this benchmark will not be met until the planned new build is completed.

Planning practical activities in science

1. Identify the main learning aim of the lesson/activity
   - A: Develop an understanding of the scientific approach to enquiry
   - B: Develop knowledge and understanding of the natural world
   - C: Learn how to use laboratory equipment and carry out standard procedures
2. Use the decision tree (see page 34) to decide how to organise the activity.
3. Check, using the grid below, that the main challenge of your practical activity is appropriate for your main learning aim.
4. If the activity falls into the 'most demanding' zone, either;
   - If aim A: Challenge the practical activity
   - If aim B: Build prior experience of equipment and procedures in previous lessons, or change equipment to something more familiar to students.
   - If aim C: Teach the new science concepts separately (ideally previously). Compare results between students to identify where errors have taken place, before using results to explain a process or phenomena
   - If unable to do these, proceed carefully!




What is the main purpose of the practical?
A: Develop an understanding of the scientific approach to enquiry
B: Develop knowledge and understanding of the natural world
C: Learn how to use laboratory equipment and carry out standard procedures
Which specific areas of the enquiry process do you want students to develop, or understand better?
Do students have sufficient knowledge and skill to carry out the practical planned?
No: Change the investigation or provide preparatory lessons (Purpose C)
Yes: Continue and plan appropriate groups for students to work in
Provide structure and support as needed to ensure students can access to areas identified as the key intention.
Final check: Are you trying to chieve Purpose B or C as well? Are you confident it does not undermine key objective by doing so?
What observation do you want to students to make?
Do students have sufficient knowledge and skill to carry out the practical planned?
No: Demonstration
Yes: Consider further points below
• Are students likely to get expected observations working independently?
• Will the observation lead to more learning if gained through independent work?
• Will it take significantly more time to do independently?
Is this best done through a demonstration, or students working independently?
What skill or technique do you want students to be better at?
Is this the first time students have been introduced to this?
No: Choose whether demonstration is required
Yes: Demonstrate first
Students carry out procedure independently. Individually, if possible.