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Science and design and technology at key stage 2

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Introduction

This report is written in response to a request for advice from the Welsh Government in the Minister's annual remit letter to Estyn for 2016-2017. The report focuses on standards, provision and leadership in the National Curriculum subjects of science and design and technology at key stage 2 in primary schools in Wales.

For this survey, Estyn inspectors visited or interviewed by telephone a broad range of primary schools across Wales, taking into account: school size, geographical location, the proportion of pupils eligible for free school meals, and linguistic and religious characteristics. Inspectors observed lessons, interviewed pupils, teachers and school leaders, and scrutinised planning and pupils' work. In addition, inspectors considered a wide range of primary school inspection evidence.

The report is for the Welsh Government, headteachers and staff in schools, local authorities and regional consortia. The report's findings will also help to inform the development of the 'science and technology' Area of Learning and Experience of the new curriculum.

Background

The National Curriculum (revised) 2008, sets out the requirements for the National Curriculum for Wales (Welsh Government, 2015).

The science curriculum at key stage 2 (Welsh Government, 2008a) notes that learners should learn to relate their scientific skills, knowledge and understanding to applications of science in everyday life, including current issues. They should learn how to recognise that they can evaluate scientific ideas by gathering information from observations and measurements. Teachers should enable learners to initiate, explore and share ideas, and extend, refine and apply their skills, knowledge and understanding in new situations. They should allow time for thinking, peer discussion and reflection. The science curriculum makes it clear that pupils should develop the skills of communication, enquiry, developing and reflecting, through the range of:

- interdependence of organisms
- the sustainable Earth
- how things work

The design and technology curriculum at key stage 2 (Welsh Government, 2008b) notes that learners should learn to design and make simple products by combining their designing and making skills with knowledge and understanding in contexts that support their work in other subjects and help develop their understanding of the 'made' world. It sets out the skills that pupils should develop in the following areas:

- designing
- making

- food
- rigid and flexible materials
- systems and control

Standards of pupils' performance are set out in level descriptions of increasing difficulty. The expected level for pupils at the end of key stage 2 is level 4. Statutory assessment arrangements for the end of key stages 2 and 3 (Welsh Government, 2016) note that: 'For key stages 2 and 3, teachers are required to assess learners' progress against the existing National Curriculum levels… for English, Welsh (if the learner has followed the Welsh programme of study) or Welsh second language, mathematics and science.' (Welsh Government, 2016, p.6).

There is no requirement to make judgements on pupils' performance at the end of key stage 2 in design and technology. However, the document 'Design and technology, Guidance for key stages 2 and 3', (Welsh Assembly Government, 2009) recognises that knowledge of the characteristics of the level descriptions will help teachers to recognise learners' strengths, as well as areas for improvement, and to plan for progression.

In 2013, Estyn undertook a thematic review of science in key stages 2 and 3.

The key messages in this survey led to the following recommendations:

Primary and secondary schools should:

1 Provide challenging science opportunities to stretch all pupils, particularly the more able, and eliminate tasks that are too easy
2 Provide more opportunities for pupils to pursue their own scientific interests
3 Ensure that assessment and marking practices provide pupils with meaningful advice on how to improve their scientific understanding and skills
4 Work with other schools to share effective approaches to teaching and assessing science

In addition, primary schools should:

5 Make sure that pupils are taught science for at least two hours a week
6 Provide training for teachers with weak science subject knowledge

In February 2015, the Welsh Government published Professor Donaldson's findings in the document 'Successful Futures, an Independent Review of Curriculum and Assessment Arrangements in Wales'. (Donaldson, 2015).

Successful Futures proposes that the curriculum in Wales should ensure that children and young people develop as:

- ambitious, capable learners, ready to learn throughout their lives
- enterprising, creative contributors, ready to play a full part in life and work
- ethical, informed citizens of Wales and the world
- healthy, confident individuals, ready to lead fulfilling lives as valued members of society

To facilitate this, the review recommends that a single organising structure for the curriculum should apply for the entire age range, from 3 to 16-year-olds. It proposes that this structure should comprise six 'Areas of Learning and Experience' and that each of these Areas of Learning and Experience should make distinct and strong contributions to developing the four purposes of the curriculum.

One such Area of Learning and Experience is 'science and technology'. The review recognises that science and technology have close links: 'science involves acquiring knowledge through observation and experimentation, and technology applies scientific knowledge in practical ways'. It outlines that this Area of Learning and Experience will draw on physics, chemistry, biology, engineering, design and technology, craft, graphic design and computer science. It further recognises that, 'For schools, this means providing children and young people with rich opportunities to develop technological skills, knowledge, understanding and attributes through designing and developing products and systems.' (Donaldson, 2015, p.50). The review also proposes the introduction of computer science as a specific component within this area.

Main findings

Standards in science

1 By the end of key stage 2, many pupils have developed a sound understanding of basic science concepts and of the nature of science. A strong feature in many schools is pupils' understanding of the need for a healthy diet and regular exercise for good health. Where standards are strongest, pupils develop a good understanding of concepts such as gravity and magnetism, and use scientific terms precisely.

2 Both boys and girls achieve similarly well and nearly all undertake scientific work equally enthusiastically. Nearly all pupils understand the importance of undertaking investigations carefully and of controlling variables. Many pupils explain their scientific enquiries, predictions and results using scientific terminology.

3 Many pupils develop their thinking skills well in science, for example when thinking about cause and effect. In one school, older pupils make predictions about which materials act best as filters before carrying out a range of investigations to test their ideas. They give coherent reasons for their predictions, based on the scientific knowledge that they have learned previously.

4 Most pupils make useful and accurate observations of their science work, and record these effectively. However, only a minority understand the need to repeat enquiries and record multiple readings to ensure the reliability of their work. A minority of pupils do not explain the reasons for their conclusions well and do not have a sound grasp of the relevant underlying scientific principles or concepts. When presenting results, too many pupils do not know which chart they should use for different types of data. A very few teachers do not understand which chart to use either.

5 Many pupils use and develop their literacy, numeracy and ICT skills well in science lessons. For example, they use their numeracy skills to measure accurately using standard units and use database software to allow them to record and analyse their findings.

6 The difference in achievement between pupils eligible for free school meals and their peers in science at the end of key stage 2 remains too wide and the gap continues to grow at level 5.

Standards in design and technology

7 A majority of pupils in key stage 2 design and make simple products by combining their designing and making skills. They are creative in their design and technology work across a broad range of topics.

8 Many pupils illustrate their design ideas using simply-labelled sketches. However, too few include accurate measurements in their plans, where appropriate. Only a few pupils plan well enough the steps they will take to complete their project.

9 In a majority of schools, pupils understand many of the different components within the design and technology curriculum, such as food and materials. However, in too many schools, pupils' understanding of 'systems and control' is weak.

Provision

10 Most schools have comprehensive plans to ensure that pupils have access to a broad and balanced science curriculum. When schools purchase commercially-available schemes of work, a few do not adapt them to ensure that pupils learn about all the areas of science in the National Curriculum.

11 Many schools allocate a suitable amount of time to teach science. However, a few have not implemented the recommendation from Estyn's review of 'Science in key stages 2 and 3' (2013) that schools should make sure pupils are taught science for at least two hours a week.

12 Where a school's science curriculum policy is unclear and leaders allow individual teachers too much choice in deciding how often pupils carry out investigative work, pupils in different classes have inconsistent opportunities to develop their investigative skills.

13 In many schools, the quality of teaching is good in science. Many teachers plan activities that focus well on developing pupils' science skills, but a minority do not challenge more able pupils enough.

14 In many cases, teachers provide pupils with detailed oral feedback during science lessons that helps them understand what they need to do to improve. In only a minority of cases do teachers focus written feedback enough on developing pupils' scientific knowledge and understanding. In only a minority of schools do teachers provide pupils with effective opportunities in science to consider how they could improve or to assess their own or their peers' learning.

15 A majority of schools provide pupils with an interesting design and technology curriculum. However, at least half of these schools do not teach all areas of the curriculum consistently. In nearly all of these cases, teachers omit the area of 'systems and control'. In a minority of schools, teachers have a weak understanding of areas of the design and technology curriculum, particularly of 'systems and control'.

16 A minority of schools do not have detailed enough planning that makes sure that pupils develop their knowledge and skills in design and technology systematically.

17 A few of the schools visited for this survey are beginning to consider the Areas of Learning and Experience described in Successful Futures (Donaldson, 2015). They are beginning to integrate subjects and adapt their planning to focus on delivering a more holistic curriculum where they teach concepts, skills and knowledge from a range of curriculum subjects in one lesson.

Leadership and management

18 Most school leaders undertake an appropriate range of self-evaluation activities to monitor standards and provision in science. However, a minority do not identify shortcomings in science robustly enough. When monitoring the quality of teaching in science, leaders too often focus on generic aspects of teaching, and actions to improve science particularly are rarely identified.

19 In a few schools, leaders do not have effective enough oversight of teacher assessment processes. Where this is the case, teachers' assessment of pupils in science is inaccurate and often over-generous.

20 Many school leaders recognise weaknesses in standards and provision for design and technology. However, only a few schools undertake robust monitoring of this subject. In only a very few schools do leaders develop suitable improvement plans to address these issues. As a result, the weaknesses often persist.

21 There are too few opportunities for teachers to develop their expertise in teaching science and design and technology. The availability of training in science by local consortia varies across Wales. Only a very few teachers receive training opportunities to help them deliver the design and technology curriculum. A few headteachers seek out expertise from other primary schools with recognised good practice to support their own schools in these curriculum areas.

22 Despite a notable difference in outcomes in science between pupils eligible for free school meals and their peers, few leaders use the pupil deprivation grant to target improvements in this subject.

Recommendations

Schools should:

R1 Make sure that science lessons challenge all pupils, particularly the more able, and reduce the achievement gap between pupils eligible for free school meals and their peers

R2 Make sure that pupils have opportunities to learn about all areas of the design and technology curriculum, particularly 'systems and control'

R3 Ensure that assessment helps pupils know what they need to do to improve

R4 Ensure that self-evaluation processes are robust and focus on pupils' subject knowledge, understanding and skills, and on the quality of teaching

R5 Provide teachers with training in the areas of science and of design and technology where they lack knowledge and confidence

Local authorities and regional consortia should:

R6 Provide more subject-specific support for teachers to improve teaching and assessment in science and design and technology and facilitate the sharing of good practice

R7 Provide more support for schools to evaluate their curriculum and plan for the development of the science and technology area of learning and experience

Standards

Investigative science

23 By the end of key stage 2, nearly all pupils understand the importance of undertaking scientific investigations carefully, demonstrating an appreciation of health and safety. They engage well and have a keen interest in practical and investigative science.

24 Many pupils are able to explain their scientific enquiries and investigations in terms of predictions, variables and results. They discuss their work confidently and respond thoughtfully to the viewpoints of others, offering their own contributions during group work and in whole-class discussions. Where this is strongest, pupils have a broad scientific vocabulary and use specific science terms confidently in the correct context.

25 Many pupils undertake scientific investigations methodically, following set structures. When provided with the opportunity, a minority suggest suitable questions to investigate at the start of science topics. They make appropriate predictions and generally understand that a prediction is not just a guess, but a considered opinion based on knowledge and previous experience.

26 A majority of pupils understand the need for a fair test enquiry, the importance of understanding which variables to change and measure, and which variable to keep the same. When undertaking planned investigations, most pupils make useful and accurate observations and record these effectively. However, only a minority of pupils understand the need to repeat enquiries and record multiple readings to ensure the accuracy and reliability of their work.

27 While most pupils write a conclusion to their investigative work, the standard of these varies too much. A minority of pupils do not draw suitable conclusions from their investigative work. They do not explain the reasoning for their conclusions well enough and do not demonstrate a clear understanding of the scientific principles behind their findings.

28 Many pupils are able to use scientific equipment sensibly. For example, they use thermometers to take readings accurately and record temperatures using the correct standard unit. Many pupils apply this understanding well, for example by measuring the temperature around the school and deciding whether the temperature in those areas is comfortable, too warm or too cold.

29 When presenting their results of science investigations, many pupils are able to identify simple patterns and trends in their findings. However, too many pupils do not know which type of graph is best to present their findings. They do not have a good enough understanding of the types of graph they should use when presenting different types of data, for example when they should use a bar chart or a line graph. A minority of pupils do not label or draw graphs accurately enough.

Science skills, knowledge and understanding

30 By the end of key stage 2, many pupils develop a sound scientific understanding. They are able to recall knowledge and talk confidently about concepts that they have learned previously in science. Both boys and girls achieve similarly well and undertake scientific work equally enthusiastically. Most work together productively to respond to set tasks and work co-operatively to solve problems.

31 A strong feature in many schools is pupils' understanding that good health requires a healthy diet and regular exercise. Most pupils can design a healthy meal and understand the need to eat fruits and vegetables and to drink water. Many older pupils understand and are able to explain the harmful effects that smoking, alcohol and drugs can have on the body.

32 Where standards are strongest, most pupils gain a good understanding of basic scientific principles, such as gravity and magnetism. They use scientific terms precisely and understand their meaning. They engage in their science lessons enthusiastically, and as a result acquire new knowledge, understanding and skills. They apply this learning to new situations confidently, not just in science but across the curriculum. For example, many pupils in Penybryn Primary School in Gwynedd explain what they have learned from researching the effects of global warming and use this scientific knowledge to explain the role of the ozone layer. Following that, they are able to apply this learning to highlight the importance of recycling to reduce carbon emissions and prepare a newsletter to persuade the local community to recycle in order to help the environment.

33 By the end of key stage 2, many pupils demonstrate a good understanding of the movement of the earth and of the relative positions and the key features of the sun and the planets in the solar system. Many pupils recall the order of the planets in the solar system correctly using mnemonics.

34 Throughout key stage 2, many pupils develop a good understanding of how to construct simple circuits and of the uses of electricity. Many are able to apply this knowledge well. Many older pupils can name a range of forces and understand the effects of gravity. However, a minority of pupils' understanding of forces such as friction and air resistance is not as strong.

35 Many pupils develop their thinking skills well in science, for example when recalling prior knowledge and understanding, thinking about cause and effect, and making inferences. For example, in Victoria Primary School, Wrexham, older pupils make predictions thoughtfully before carrying out a range of investigations, such as predicting which materials act best as filters, or how the speed of stirring may affect the rate that a solid dissolves in a liquid. They give coherent reasons for their ideas, based on scientific knowledge that they have learned previously.

36 In science lessons, many pupils use and develop their communication skills effectively. They listen to each other's views sensibly and are able to communicate their ideas clearly, explaining their thinking to their peers. This is good feature in many schools.

37 Many pupils use their numeracy skills well in their investigative work and measure accurately using standard units and analyse the data collected. For example, when undertaking practical work, pupils at Ysgol Gymunedol Llwyn-yr-Eos in Ceredigion measure and record the height of pupils to the nearest centimetre and convert this to millimetres and metres. Using this information, they identify the tallest and shortest pupils and calculate the difference in height correctly. They use their numeracy skills to determine the mean height of the group and create a graph with this data, which they label correctly.

38 Many pupils use their ICT skills to undertake subject specific research and to record their findings. Many pupils use the Welsh Government's Hwb resources confidently, for example to access database software that will allow them to record their findings. In Abernant Primary School in Rhondda Cynon Taf, pupils record results from their investigations into forces accurately on laptop and tablet computers using Hwb. Pupils that are more able develop their own forms for recording information, paying close attention to the data that they need to record and the use they will make of it. From this, they create a useful range of graphs and charts that display their findings.

39 The number of pupils who are assessed by teachers as achieving achieved the expected level 4 or above in science has increased year-on-year for at least the last five years, with more pupils achieving this level in science than in English or mathematics (see appendix 1).

40 At the expected level, the gap between pupils eligible for free school meals and their peers has decreased a little, but at the higher level the performance gap has increased. In schools with a higher percentage of pupils eligible for free school meals, substantially fewer pupils achieve the expected or higher level compared with numbers in schools with a lower percentage of pupils eligible for free school meals (see appendix 1).

Standards in design and technology

41 In general, a majority of pupils in key stage 2 design and make simple products. They are creative in their work across a broad range of interesting topics. Many pupils recall previous learning well, acquire new knowledge, and apply skills previously learned to new situations. For example, pupils apply their knowledge of the water cycle gained in their science lessons, to plan, design and make a model to explain the water cycle.

42 Many pupils are able to gather information from a range of sources to help them generate their initial design ideas. Most pupils use their ICT skills to support this, for example by undertaking focused research using the internet.

43 Many pupils illustrate their ideas using simply-labelled sketches, outlining what they are going to make and listing the resources they will need to complete their projects. However, too few include accurate measurements in their plans. Only a few consider the making process in enough detail and how they plan to undertake and complete their project. In the minority of schools where pupils demonstrate high-order design skills, most pupils plan using a variety of labelled sketches that include appropriate measurements. They choose resources at the planning stage, and make choices based on their developing knowledge of how they should use them. They consider carefully their method of production.

44 A majority of pupils evaluate their final product, stating what improvements they would make, but few pupils evaluate their design as it develops. Too few pupils focus enough on evaluating the quality of their product and the process, taking into account their original design brief. In many cases, pupils' evaluations focus unnecessarily on considering whether they worked well individually or as a team, or whether they enjoyed the project.

Case study 1: Victoria Primary School, Wrexham – Developing science and design and technology skills using real-life contexts

Information about the school

There are 466 pupils on roll aged between 3 and 11 years. Many pupils speak English as their first language, and around 20% of pupils are from minority-ethnic backgrounds. About 13% of pupils are eligible for free school meals, which is lower than the national figure. The school identifies around 15% of pupils as having additional learning needs.

Context and background to the practice

Leaders wanted to ensure that the curriculum would develop pupils' design and technology and science skills and provide stimulating, real-life contexts in which pupils could develop and apply their learning.

Description of activity/strategy

After a successful entry into the Formula 1 Primary School Challenge in 2014, leaders decided to use the project to help develop pupils' design and technology and science skills further. The project involves designing and manufacturing the fastest car possible, copying the design and engineering processes employed by real engineering companies. It allows pupils the opportunity to:

- take part in a fun, hands-on Science, Technology, Engineering & Maths activities (STEM)
- tackle real-life problem solving and learning
- develop design, manufacturing, teamwork, communication & business skills

School leaders organised training for staff, so that they had the skills to develop pupils' learning, for example in using bespoke software programmes and cutting machinery. Teachers liaised with the head of technology and engineering at a local secondary school. Staff from the secondary school visited the primary pupils to introduce the project and provide guidance. Teachers also used the skills of Year 6 pupils, who had previously undertaken a similar project, to support other pupils to use the computer software and cutting machines.

Pupils decided on team roles, such as manufacturing engineer, design engineer and graphic designer. They had useful opportunities to develop their literacy, numeracy and ICT skills, for example when writing emails to local companies requesting sponsorship and when budget planning.

Pupils used their scientific and research skills well, to investigate the main factors that affect the speed of a vehicle, focusing on mass, aerodynamics and friction. They incorporated their findings into the success criteria for their design. They used their design and technology skills to create detailed plans of their ideas and then used the computer-design software and their ICT skills to create nets of their designs.

The team tested their designs:

- measuring and experimenting with the weight of different designs
- using a fan to test the aerodynamics of each vehicle, measuring how far they travelled
- experimenting with different sized wheels, focusing on how friction affected the speed of the vehicle

This allowed them to evaluate their ideas and refine their designs. They made amendments to the vehicle, including adding a spoiler to help hold the vehicle onto the ground. Using their design and technology skills, the pupils built their final vehicle. Entering the competition, they were successful in the regional finals, winning first place in 2016. They also won first place for the fastest car and best design.

Pupils compiled their work into a portfolio that they could exhibit and created a presentation, developing their literacy and numeracy skills.

Impact on provision and standards

- Nearly all pupils undertake scientific investigations methodically, following prescribed frameworks.
- There is a clear progression in the development of pupils' independent skills, from more dependency in Year 3 to greater independent working in Year 6.
- Most pupils plan, make and evaluate their design and technology work confidently. Most use their problem-solving skills well and ask effective questions to help them improve their work.
- Most pupils' understanding of the different components within the design and technology curriculum is strong.
- Pupils' attitudes to learning in science and technology, their interest in their work and their engagement in their tasks are very good.

45 When making their products, most pupils follow carefully the instructions provided by the teacher. Where pupils' standards are best, many pupils prepare these instructions themselves.

46 In a majority of schools, many pupils carry out a suitable range of practical food preparation tasks safely and hygienically, and consider the importance of healthy eating and a balanced diet. At the end of key stage 2, most pupils sort different foods into groups and understand their basic nutritional properties. In many cases, pupils link their learning about food and health in science with that in design and technology, for example when considering what toppings to put on a pizza.

47 Many pupils apply their design and technology skills when undertaking activities to develop their entrepreneurial skills. For example, pupils at Ysgol y Llys in Denbighshire apply their research, designing, making and evaluating skills while preparing and making 'bath bombs' to sell as part of their entrepreneurial activities. Similarly, they develop cooking skills by following recipes, weighing ingredients accurately, setting the correct temperature and adhering to cooking times.

48 In a majority of schools, pupils' understanding of many of the different components within the design and technology curriculum, such as food and materials, is suitable. In too many schools, pupils' understanding of how to use programmable, computer-control systems that can create, test, modify and store instructions to control events within 'systems and control' is weak.

49 Many pupils understand how to build simple low-voltage circuits within products. For example, pupils in lower key stage 2 at Llanyrafon Primary School, Torfaen, build circuits with buzzers and bulbs into model houses they have designed. They make simple switches, for example one that operates as a simple intruder alarm, with wires and paper clips.

50 Many pupils use their communication skills well in design and technology. They talk confidently about work that they have done and use what they have learned in new situations. For example, pupils at Gorseinon Primary School, Swansea, use their understanding of floating and sinking to help them plan work on submarines.

51 Most pupils apply their numeracy skills appropriately, particularly when undertaking 'enterprise' schemes. Many pupils calculate the costs of the raw materials needed to make products. They monitor the total cost of their products and calculate a suitable selling price to ensure they make a profit. In a minority of cases, they integrate this with their ICT skills, keeping useful accounts using spreadsheets.

52 Many pupils use their ICT skills well in design and technology. Most undertake useful background research on the internet to help develop design ideas. For example, they research car designs independently and use this to help design their own, air-powered buggy. A minority of pupils use computers and tablet computers to help them create their designs.

53 Many pupils develop their thinking skills in design and technology and adapt their ideas well in practical work. For example, pupils at Ysgol Gynradd Gymraeg Castellau in Rhondda Cynon Taf suggest making the model of a skull using papier-mâché formed over a balloon, taking care to blow enough air into the balloon to achieve a certain circumference.

54 Nearly all pupils' attitudes to learning in design and technology, their interest in their work, their ability to sustain concentration, and their engagement in their tasks are very good. They participate well and with enthusiasm.

Provision

Science curriculum planning

55 Nearly all schools have comprehensive long- and medium-term plans to ensure that pupils have access to a broad and balanced science curriculum. Generally, these plans cover the range of learning set out in the National Curriculum: 'the interdependence of organisms', 'the sustainable Earth' and 'how things work' (Welsh Government, 2008a).

56 In many schools, the planning of science topics has been aligned with broader themes or topics that cover a half term or term. For example, when studying the Second World War, pupils may learn about forces in the context of aeroplanes and flight, or about food and nutrition from the perspective of rationing. In these cases, pupils often make useful links between their learning across many subjects and apply skills they have learned in one lesson to other curriculum areas. This encourages pupils to draw out similarities between subjects and reinforces key concepts and understanding.

57 A majority of schools use commercially-available schemes of work to help them plan their science curriculum. In many cases, where schools have used such a scheme, teachers have adapted and made useful additions to the plans to ensure that they cover all areas of the science curriculum progressively and systematically. In the few cases where schools have not adapted the schemes carefully enough, pupils do not have opportunities to learn about all of the areas of science set out in the National Curriculum.

58 Many schools allocate a suitable amount of time to the teaching of science. However, a few have not followed the recommendation from Estyn's review of 'Science in key stages 2 and 3' (2013) that schools should make sure that pupils are taught science for at least two hours a week.

59 In many schools, the curriculum offers an appropriate balance between the direct teaching of science concepts and skills, and opportunities for pupils to undertake investigative work. In the most effective cases, staff teach the knowledge and scientific skills before providing pupils with an investigative task to enhance their understanding and further develop their skills.

60 In a majority of schools, long-term planning identifies useful science investigations for pupils to undertake during each science topic. This ensures that all pupils in these schools have consistent opportunities to develop important science skills as they plan and carry out scientific inquiries.

Case study 2: Ysgol Gynradd Castell Nedd, Neath – Planning an effective science curriculum

Information about the school

Ysgol Gynradd Gymraeg Castell-Nedd is a Welsh-medium primary school in Neath, in the county of Neath Port Talbot. There are 387 full-time pupils on roll, 56 of whom attend part-time in the nursery. Around 84% of pupils come from homes in which English is the main language.

Around 10% of pupils are eligible for free school meals, which is lower than the national average. A very few pupils come from minority-ethnic backgrounds. The school identifies about 10% of pupils as having additional learning needs. This is also lower than the national figure. No pupil has a statement of special educational needs. The school introduces the teaching of English formally at the beginning of key stage 2.

Context and background to the practice

To ensure the systematic development of science-specific skills for pupils in key stage 2, leaders have changed the way the science curriculum is organised. This includes teaching science in a series of science skills lessons that lead to a final investigation in the form of a question or scenario, where pupils apply the skills that they have learned.

Description of activity/strategy

Teachers in key stage 2 have mapped out in detail the skills and the range from the science curriculum and have distributed the teaching of specific skills between ‘lower’ and ‘upper’ key stage 2 carefully. They provide support for less able pupils and challenge to pupils of higher ability.

Throughout key stage 2, teachers focus on developing pupils’ science investigative skills, such as predicting, reflecting, evaluating and presenting information, for example using graphs or charts. Pupils develop and practise these skills in a series of lessons before they complete science investigations. As a result, pupils develop science skills that allow them to undertake investigations effectively. Teachers evaluate these investigations focusing on pupils’ understanding of science specific skills and their ability to apply them to their work. When they identify a weakness, teachers plan targeted lesson to improve pupils’ knowledge and skills in those identified areas.

As a result, different classes are able to target different science skills, in line with their particular needs. For example, one teacher’s evaluation identified that understanding the best graphs to use to present different types of data caused difficulty for a majority of pupils. They planned a series of lessons to address this issue. Pupils had opportunities to learn about the types of graphs that they could use for different purposes. They then created a range of different graphs using various sets of data. Those who were not

confident in plotting a line graph had further exercises in order to ensure that all pupils understood. Due to this support, nearly all pupils were confident and able to draw graphs independently and correctly, when conducting their next investigation.

Teachers plan science sessions so that pupils have many opportunities to develop useful literacy, numeracy and ICT skills. When evaluating their lessons, they identify the pupils who need to improve particular skills. This means that they are able to plan learning that focuses on specific pupils to allow them to develop these skills.

For example, teachers focus on ensuring that the literacy skills pupils use in science reflect the standards they achieve in Welsh. Where standards of pupils' writing of their scientific method are not strong enough, teachers plan language sessions that analyse suitable verbs and phrases, before revisiting this work. In addition, they plan comprehension tasks that focus on developing their knowledge from the range element of the National Curriculum.

Teachers and pupils work together to reflect on what causes pupils difficulty in science. Teachers then prepare bespoke tasks to help them. For example, where a pupil draws attention to the fact that they have difficulty in reading the scale on a thermometer, teachers plan suitable follow-up work.

Impact on provision and standards

- Many pupils' confidence in science has improved.
- Nearly all pupils enjoy science.
- Nearly all pupils have sound scientific understanding and can analyse and explain their scientific enquiries confidently in terms of variables, predictions and results.
- Nearly all pupils recall previous scientific learning confidently and develop their ideas clearly based on their previous knowledge/

61 In a few schools, while the content of the science curriculum is clear and mapped out well, leaders expect individual teachers to decide when and how often pupils should carry out practical or investigative work. In these schools, it is often the case that pupils in different classes have inconsistent opportunities to develop their investigative skills and their experiences lack continuity or progression.

62 Many schools have clear guidance within their long- and medium-term planning that identifies opportunities for pupils to develop and practise important literacy, numeracy and ICT skills. In a few schools, these plans are not clear or useful enough. In these cases, planning for these wider skills may consist of an icon or letter in the plans to indicate that pupils may use a skill during a particular lesson or activity, without identifying clearly enough which aspects of the skills they may develop or how. As a result, a few pupils do not have strong enough opportunities to consolidate or improve these skills during science lessons.

63 In many schools, teachers often use science as the context for pupils to produce extended pieces of writing, such as accounts of investigations or reports and presentations. Most teachers give pupils a wide range of opportunities to develop oracy skills, through discussing their ideas with the class or explaining their scientific thinking.

64 In most schools, teachers help pupils develop numeracy skills through science work. They often plan for pupils to have opportunities to measure, record and analyse data from a range of sources. For example, they chart the distance travelled by a buggy down slopes of a different gradient, and compare differing results. In a few cases, teachers do not understand the uses of different types of chart or graph and cannot guide pupils on which to use.

Science enrichment and experiences

65 Many schools use various resources cleverly to supplement the science curriculum and provide pupils with real-life experiences. For example, in Ysgol Brynsierfel, Carmarthenshire, the school has strong partnerships with parents, governors and other agencies, and often uses their expertise to enhance the curriculum. A governor who works for an aeroplane manufacturer presented a highly motivating talk on the use of satellites and their effect on pupils' lives in terms of mobile phones and satellite navigation systems. As a result, pupils gained a deeper understanding of how science affects their daily lives. The school also visits the National Botanical Garden of Wales and the local Wildfowl and Wetlands Trust Centre at Penclacwydd to develop its work on living things.

66 In most Welsh-medium schools, pupils learn science through the medium of Welsh in key stage 2. In a minority of schools, teachers present pupils with scientific terminology in Welsh and English, and provide them with opportunities to record their work in either or both languages. This enhances pupils' bilingual skills, builds on their ability and confidence to discuss their work in either language, and prepares them for studying the subject in either language in the future.

67 Many schools organise a range of trips, activities and visitors that enrich their science curriculum and help pupils develop an enthusiasm for the subject. For example, many schools make visits to science discovery centres where pupils undertake a broad range of science activities that they may not be able to access in school, such as learning about the solar system in a planetarium.

68 A majority of schools arrange visitors who can supplement the curriculum, such as providers that bring animals to school for pupils to see, or those that conduct large-scale investigations for groups of pupils. For example, at Cwmrhydyceirw Primary School in Swansea, discussions with pupils about their learning led to leaders organising enrichment afternoons in science. They arranged for an outside provider to attend the school for one afternoon each month. In small, adult-led groups, pupils have worthwhile experiences to engage in practical science activities, such as 'Electricity and Forces'. Pupils look at how systems convert electricity for everyday use, create their own circuits, interact with plasma balls, discover 'sticky' static electricity, and make their own static energy 'chambers' to take home. Where these are most effective, the provision links well with the school's taught curriculum and supplements rather than replaces science lessons.

69 A minority of schools work well with their local secondary schools to help them deliver their science curriculum. Where these links are most effective, they allow the primary school to access more diverse resources, such as science laboratories and engage the support of specialist science teachers.

70 A minority of schools organise and run after-school science clubs for pupils in key stage 2. Many of these are run by teachers and focus on providing useful opportunities for pupils to undertake practical science tasks in small groups. These clubs support pupils' learning and develop their enthusiasm for science.

Science teaching and assessment

71 In many schools, teachers provide pupils with appropriate opportunities to consider what they wish to learn at the start of each science theme. In a very few cases, where pupils' ideas do not fit in with the science programme of study, teachers give pupils opportunities to complete mini projects in school or as homework. In nearly all cases where pupils are involved in shaping their own learning, they are highly motivated and engage eagerly in their lessons. In a few schools, pupils have limited opportunities to contribute their ideas or to have a say in what they want to learn in science.

72 In the best cases, teachers allow pupils to discuss their ideas, and build on their interests to enhance their science lessons. For example, at Ysgol Penybryn in Gwynedd, all pupils review their learning through a discussion board on Hwb. This is an innovative approach to securing pupil voice and engages pupils. These reviews help direct pupils' learning and enhance the science provision. For example, through the discussion board, feedback showed that pupils did not know what happens to recycled materials. This helped teachers to plan the next step in pupils' learning, engaged pupils well and contributed to their enthusiasm for the subject.

73 The quality of teaching in science lessons in many schools is good. Many teachers plan activities that focus well on developing pupils' science skills. They manage resources and practical lessons effectively. Many teachers plan and teach a useful balance of investigative science and understanding science concepts.

74 In many schools, teachers plan lessons that enthuse pupils, such as at Ysgol Llwyn yr Eos in Ceredigion, where teachers often begin science lessons for older pupils with a 'wow introduction'. For example, in one lesson, pupils returned to class after lunch and were not able to enter as someone had sealed off the area with 'police tape' to create a crime scene investigation. The teacher then asked the pupils to take the role of detectives and solve a case using their science skills and the data available, such as height and footprint size. As a result, all pupils were engaged and analysed a wide range of science data effectively.

75 In the few cases, where teaching is not as strong, a few teachers lack confidence in dealing with scientific concepts and methods, and do not engage pupils in their learning sufficiently.

76 In a majority of science lessons, teachers provide many pupils with work that is of a sufficiently challenging level. This often includes additional adult support for pupils with additional learning needs. These support processes give the majority of pupils access to appropriate science learning.

77 Nearly all schools maintain records of pupils' progress in science. However, a minority of teachers do not use this information well enough to provide appropriate challenge to more able pupils. In many cases, even where teachers have a higher expectation of these pupils, they often only require them to explain or write more, rather than providing them with more advanced science challenges.

78 In many science lessons, teachers provide pupils with useful oral feedback. They ask pupils a broad range of open and engaging questions and, in many cases, use pupils' responses well to help explain concepts further and address possible misunderstandings.

79 When written feedback is required, its quality in science varies too much within and across schools. In most cases, the feedback recognises what pupils have achieved and offers suitable praise. However, in only a minority of cases is it focused enough on developing pupils' scientific understanding or on helping pupils understand what they need to do to improve.

80 Where feedback is strong, it is diagnostic, aids improvement, and focuses on science skills and knowledge. Where written feedback is most effective, teachers then provide pupils with opportunities to respond to their comments.

81 In a majority of schools, there are suitable opportunities for pupils' peer and self-assessment, particularly in upper key stage 2. Many of these focus on allowing pupils to assess their own learning against given success criteria, both during and at the end of lessons. In these cases, most pupils do this well and are beginning to develop a useful understanding of what improves the quality of their science work. However in a few cases, pupils focus too little on their learning, saying whether they think they did well, or focus too much on whether they consider that they worked effectively on their own or in a team.

82 In a minority of schools, teachers provide pupils with formative assessment opportunities in science lessons, such as the chance to assess and measure the success of their own learning or that of their peers, or to consider how they could improve.

83 In nearly all schools, teachers track and monitor pupils progress in science. Where this is most useful, leaders monitor pupils' books and learning, and scrutinise the teachers' assessments in comparison to their own judgements. However, in a minority of cases, the oversight of teachers' ongoing assessment of pupils' learning is not robust enough. In these cases, the information held is often not accurate enough, and teachers and leaders do not have a good enough understanding of pupils' progress and attainment.

Design and technology curriculum planning

84 A majority of schools provide pupils with an interesting design and technology curriculum. They have developed long- and medium-term plans to ensure that as pupils move through key stage 2 they develop the skills and knowledge set out in the Design and technology National Curriculum. However, at least half of these schools do not ensure that they teach all of the areas of the curriculum, and it is nearly always 'systems and control' that is left out.

85 A minority of schools do not have appropriate long- or medium-term plans to ensure that pupils develop their knowledge and skills in design and technology systematically. In these schools, few pupils develop their skills and knowledge in this area of the curriculum strongly enough.

86 In many schools, pupils have useful opportunities to develop their skills and understanding in relation to food. Most pupils plan and carry out a broad range of practical food preparation tasks. When undertaking these exercises, nearly all schools help pupils to understand the importance of healthy eating and they plan for pupils to learn about nutrition, keeping fit and consuming a balanced diet.

87 In many schools, teachers help pupils to use a range of tools and materials, for example wood and cardboard to build structures, such as rockets and buggies. They plan and deliver lessons to allow pupils to learn how to use simple tools and equipment safely. For example, pupils learn how to cut wood using a junior hacksaw and the importance of always wearing suitable safety equipment such as googles.

88 In a majority of schools, pupils learn to incorporate simple low-voltage electrical circuits within products. However, in only a few schools do pupils have enough opportunities to learn about computer control and programmable systems that store instructions, often because of teachers' limited knowledge or confidence in this area of the curriculum.

89 In the few best cases, the school's curriculum gives pupils opportunities to develop these skills well as they move through key stage 2. They learn to programme toy buggies, using freely available software, such as 'scratch'. They are able to consider how the programme they write controls their buggy and use this knowledge to programme the buggy to move around a set course. In the best cases, pupils include other components into their buggy, such as light sensors. Using these, they are able to programme their buggy to stop or take a detour when it senses an obstruction.

Case study 3: Malpas Court Primary – Developing provision for STEM

Information about the school

Malpas Court Primary School is in the city of Newport. The school has 226 pupils, including 37 part-time pupils in the nursery. There are 10 full time teachers for nine classes. There is a resource base for 16 pupils with speech and language impairment.

Around 40% of pupils are eligible for free school meals. This is well above the national average. Around 40% of pupils join or leave the school during the academic year. No pupils speak Welsh as their first language and 14% of pupils have English as an additional language. The school identifies approximately 50% of pupils as having additional learning needs. This is considerably higher than the national average. A few pupils have a statement of special educational needs.

The school is currently a 'curriculum pioneer school'. This means that it is working with the Welsh Government and other curriculum pioneer schools to develop and to pilot a new curriculum for Wales.

Context and background to the practice

To fulfil their vision of developing enquiring minds while extending pupils' knowledge of the local environment and the wider world of work, the school developed a science and technology resource room (called the STEM room). Using this space and associated resources, staff provide pupils with opportunities to investigate the world around them in a safe and systematic way.

Description of activity/strategy

Following consultation with pupils, it was clear to leaders that many pupils wanted more opportunities in the curriculum to learn about science and technology. Leaders decided that a way forward would be to develop a STEM room at the school.

Leaders planned the STEM room as a central, sustainable resource to provide learning opportunities for pupils in the Foundation Phase and key stage 2. The room allows pupils to develop science and design and technology skills while promoting decision-making and collaborative learning. It enables pupils to apply their literacy, numeracy, ICT and thinking skills to science and design and technology challenges.

Staff identified a storage room that they had not used for some time, cleared it and set about reorganising it into a useful learning space. Although the school had limited financial resources, staff worked diligently to ensure the room was equipped with suitable resources, such as sets of building blocks. Staff attended free training courses, for example to develop their skills in understanding the coding that controls the models that pupils build.

Within the room, pupils have access to a wide range of interesting resources including:

- challenge bags that contain resources linked to the science and design and technology curricula; each bag contains all the resources necessary to complete a design and build challenge, for example to build a cardboard robot and make it balance on a very small area, like a fingertip
- STEM boxes that provide a group of pupils with one investigation
- recycled materials that pupils can use to build their own designs
- building blocks with motors and electronic component that pupils build and programme
- Old computers and mechanical equipment that pupils can take apart to learn how they work
- Design and technology materials and tools

These provide useful opportunities for pupils to be creative, solve problems, plan, build and evaluate. Staff use this room and its resources to plan lessons that they base on real-life situations, where pupils can apply and develop skills, which they will use in a working career.

The pupils have access to the STEM room throughout the school week and during the STEM club. During lunch and free time, they may go there independently to complete challenges as well as test, evaluate and improve their investigation. Pupil-led activities linked to wider school topics take place weekly in the STEM room. Staff have set up a wellbeing group linked to the STEM room for small groups of identified pupils. Working in groups with a learning support assistant, these pupils complete STEM challenges and learn to share, work as a team and help each other. They are also working with groups of pupils from the school's 'speech and language' base on improving their communication and collaborative working skills, using these resources.

Impact on provision and standards

- The STEM room is an ongoing project but it is already having a discernible impact on improving classroom practice and raising standards.
- Pupils are taking ownership of their education and have become more independent learners.
- Pupils' standards in science and design and technology have improved.
- The STEM room allows pupils to be more creative in their lessons, as they shape their own investigations.
- The resource helps pupils develop a stronger understanding of recycling and resource management.
- Through the wellbeing sessions, pupils have improved their collaborative and social skills.
- Successful partnerships with the local university, national supermarket chain, cosmetics shop, and others have allowed pupils to develop a comprehensive understanding of sustainability and have provided real-life contexts for pupils' work.

90 Many schools have enough resources to support the delivery of a majority of the design and technology curriculum. However, too few schools have enough up-to-date equipment and construction kits that can be controlled using computers to give pupils opportunities to develop their skills in the 'systems and control' element of the curriculum.

Enrichment and experiences

91 Many schools organise activities that enrich and broaden their design and technology curriculum, such as arranging visitors to the school and co-ordinating 'enterprise' activities where pupils use their design and technology skills to make and then sell products. Only a very few schools provide extra-curricular clubs that focus on providing pupils with experiences that enhance their design and technology skills.

Design and technology teaching and assessment

92 In many schools, the quality of teaching in 'food' and in 'rigid and flexible materials' of the design and technology curriculum is good. Many teachers plan and develop

interesting contexts for pupils' learning and consider carefully the skills that pupils need to be able to access these elements of the curriculum. For example, when studying forces, pupils design and make rockets that allow them to test their ideas. In many schools, teachers often incorporate pupils' ideas into the design and technology curriculum. This contributes to pupils' enthusiasm for the subject.

93 In a majority of schools, teachers do not teach the element of 'systems and control' regularly or well enough. In many cases, this is due to a lack of teacher confidence or knowledge of this area of the design and technology curriculum.

94 In only a minority of schools do teachers track pupils' skills development in design and technology. Many teachers keep ongoing records in this subject. However, in too many cases these records are only used to monitor whether or not pupils have undertaken a skills based activity. For example, they record whether pupils have used a particular technique rather than focusing on the standards pupils reach or how much progress they make in design and technology.

95 In most schools, teachers do not consider well enough pupils' differing abilities when planning design and technology lessons. In most cases, nearly all pupils undertake the same activity.

96 In many design and technology lessons, teachers provide pupils with useful oral feedback and advice. This allows pupils to understand where their work is effective and where it needs to be improved. However, in only a few of cases do teachers provide written feedback to pupils on their projects that focuses well enough on how they could develop and improve their design and technology skills.

97 A majority of pupils have opportunities to assess the standards of their own design and technology work and that of their peers. However, in a minority of schools these practices are not consistent enough to help pupils make progress.

Successful Futures – A curriculum for Wales

98 A few of the schools visited for this survey have begun to consider the nature of the proposed curriculum, as set out in Successful Futures (Donaldson, 2015). In these schools, teachers are beginning to plan and trial sequences of lessons that cover a range of current National Curriculum subjects, such as science, design and technology and ICT. They develop learning contexts that allow them to focus on providing pupils with a broad range of knowledge and skills that are not compartmentalised. For example, in Abernant Primary School, Aberdare, older pupils design and build rockets in design and technology to help them learn about forces in science.

99 Most schools teach science and design and technology as separate subjects, often set within the same theme. In a growing number of schools, teachers are beginning to teach skills and knowledge common to the two subjects within one task or project. For example, pupils in Years 3 and 4 may learn about the basics of electricity and circuits in science lessons before using their knowledge to design and build a simple alarm to catch Father Christmas as he comes down the chimney.

100 A few schools are now beginning to consider the curriculum in terms of the Areas of Learning and Experience as set out in Successful Futures (Donaldson, 2015). For example, in Ysgol Gynradd Gymraeg Cwm Gwyddon, Caerphilly, leaders have created staff teams in line with the six Areas of Learning and Experience. This allows them to consider how to adapt their long-term planning so that they can focus on delivering the four core purposes[1] and create a more holistic curriculum as set out in Successful Futures (Donaldson, 2015). The school has already planned and delivered a successful pilot project, based on sorting and classifying living things, in all classes and with its local secondary school.

[1] See Glossary

Leadership and management

Science

101 In many schools, leaders understand the importance of science as a core area within the curriculum. They appreciate the need for pupils to develop an understanding of scientific principles and how to test these in practical situations. For example, in a majority of schools, leaders ensure that in key stage 2 most pupils have the opportunity to undertake a broad range of practical science investigations. However, in a minority of cases leaders do not consider whether their curriculum contributes strongly enough to developing understanding of these principles.

102 In many schools, leaders have oversight of the balance of the curriculum and the time allocated to different subject areas. However, in a few schools, the time allocated to science is not monitored closely enough. A very few schools provide barely an hour each week, while others provide more than double this time. Where teachers devote too little time to this subject, pupils often do not develop a strong enough understanding of all the areas of the science curriculum.

103 Models of leadership in science vary across primary schools. In many schools, a subject leader for science, often a senior leader, takes responsibility for most leadership activities in this subject area. In a few schools, this person also responsible for design and technology.

104 In a few schools, headteachers are beginning to form small teams to oversee subject areas, rather than giving this responsibility to an individual. In these cases, a group of staff, usually led by a senior leader, oversee a number of linked curriculum subjects. In the most effective cases, schools are able to draw upon the expertise of a range of different colleagues to lead and support staff in various areas of the curriculum.

105 In many cases, where these teams exist, leaders and teachers are beginning to plan for and deliver learning activities that develop pupils' skills in a number of subjects in the current National Curriculum, such as activities that develop pupils' science, design and technology and ICT skills together. For example, Llanyrafon Primary School, Torfaen, has one leader for science and design and technology. This leader has begun to consider how to integrate elements of these curriculum areas and improve provision. As a result, pupils learn about the scientific principle of fair testing using different types of glue while designing and making a model World War 2 shelter using their design and technology skills.

106 The activities that schools use to help them evaluate the quality of learning and teaching in science are broadly the same, such as scrutinising books and listening to learners. However, schools differ in terms of who carries out these activities, and how. In many cases, subject leaders for science organise monitoring activities and carry out a majority themselves. However, where leaders ensure that all teachers contribute to self-evaluation activities, such as the scrutiny of pupils' science work, teachers gain a better understanding of what constitutes good standards, and what strong progression looks like.

107 Nearly all headteachers and many senior leaders undertake lesson observations to assess the quality of teaching in their school. They usually conduct a few of these observations in science lessons. However, where these observations take place, leaders focus mainly on general teaching skills and on the standard of pupils' literacy and numeracy. In only a very few cases do leaders focus specifically on the quality of the teaching in science. As a result, weak teaching in science is often not identified.

108 In a minority of schools, self-evaluation processes do not highlight standards and provision in science, or where and how they need to improve. In a very few schools, leaders undertake little monitoring of science.

109 Only a few schools identify shortcomings in science in their self-evaluation processes. This seldom appears in school improvement plans as a priority. In the few cases where schools highlight the need to improve pupils' skills in this area, such as the need to improve their ability to undertake science investigations independently, schools generally plan for this well.

Case study 4: Ysgol Gymraeg Castellau, Rhondda Cynon Taf

Information about the school

Ysgol Gynradd Gymraeg Castellau is in the village of Beddau, in Rhondda Cynon Taf. There are 263 pupils on roll. The school provides bilingual education for pupils aged between 3 and 11 years. Welsh is the main medium of learning. About 14% of pupils come from Welsh-speaking homes.

The three-year average for pupils who are eligible for free school meals is 7.5%. This is below the national average. The school identifies around 17% of pupils as having additional learning needs, a little lower than the average for Wales.

Context and background to the practice

At Ysgol Gynradd Gymraeg Castellau, leaders have targeted standards in science as a key area for improvement. To support this they have developed systems to ensure that the monitoring of pupils' science learning has a clearer focus. For example, they update the school's book scrutiny format to focus more directly on standards in science and to ensure that staff respond to previous recommendations for improvement. The aim is to develop a monitoring system that evaluates the available evidence, while providing commentary relating to standards in science (including analysis of different groups of learners). Leaders designed this system to contribute to a more holistic approach to monitor standards, secure accountability and target performance management.

Description of activity/strategy

Leaders complete one book scrutiny and one other monitoring exercise in

science, English and mathematics each term (with additional monitoring to cover cross-curricular literacy, numeracy and ICT separately). Subject leaders collect all pupils' science books and select a sample for scrutiny. The school uses an online tool for assessment, which guides leaders in selecting books for scrutiny. It selects the current highest, lowest and median pupil, and pupils on the border of National Curriculum level descriptors, such as pupils whose performance spans the border between the lower than expected level 3 and expected level 4 at the end of key stage 2.

Leaders begin with a review of the previous cycle's areas for development. This ensures that, at the start of the monitoring process, they evaluate and comment on progress made against previous targets for improvement in science. Following this, leaders scrutinise evidence and make evaluative comments about pupils' standards and progress, based on the scrutiny of their work and the progress they have made in their books. They focus on individual pupil progress, the performance of different groups of learners (such as boys and girls), and how well teachers adhere to the school's schemes of work. Leaders also analyse the school's online assessment information during this process to ensure that there is a close correlation between teachers' science assessments and other available evidence.

Leaders comment on whether they agree or disagree with the current teacher assessment. There is also scope for the science subject leader to comment on wider aspects of teaching and learning within the subject, such as differentiation, assessment for learning and quality of teachers' feedback to pupils. They complete the monitoring process by identifying any new areas for development. They focus these well to improve standards of attainment.

This more rigorous and targeted monitoring process has led to improved standards in science by identifying areas for development and staff training needs. Examples include:

<u>Identifying specific science skills that were underdeveloped</u>

As a result, leaders focused in-house training on ensuring that teachers improved their understanding of science 'predictions' and provided examples of suitable activities that they could use with pupils at National Curriculum levels 3, 4 and 5.

Leaders developed similar training activities and discussion to develop teachers' understanding of scientific 'analysis', 'explanations' and 'drawing conclusions', with the subject leader, again providing exemplar materials of activities and lessons to develop these skills.

<u>Identifying training needs</u>

Analysing the outcomes of monitoring activities and discussing these with staff help leaders to identify their training needs. Leaders then source a

wide range of training activities to match each individual's specific needs, for example ensuring that teachers access training to enable them to focus more successfully on developing suitable 'success criteria' for pupils in science. Previous monitoring had demonstrated that, while teachers focused well on literacy and numeracy, they were not always focusing well enough on evaluating pupils' success in terms of key science skills. As a result, leaders were able to generate science focused, exemplar lesson objectives and success criteria and share these as pupil-friendly posters in each class.

Improving teacher assessment

Previous monitoring identified inconsistencies in teacher assessment in science. As a result, leaders arranged additional internal moderation sessions. They scrutinized pupils' work from across key stage 2 and compared this with information on the online-assessment tool. This allowed for open professional dialogue and an improved understanding by teachers of standards that exemplified a particular level. This was particularly useful for those teachers who had not previously taught in Year 6 and had not contributed to end-of-key stage assessment. It also ensured that Foundation Phase teachers were clear about pupils' progress throughout their education.

Impact on provision and standards

Over the last four years, most pupils achieve at least the expected level 4 in science at the end of key stage 2. Pupils' performance at the levels above those expected have improved significantly year-on-year over the last four years. In 2013, 16.7% of pupils achieved the above-expected level 5. By 2016, over half of all pupils in Year 6 achieved this level.

110 In a majority of schools, senior leaders, including headteachers, monitor the levels awarded in teacher assessment of science at the end of key stage 2. They support teachers to scrutinise pupils' work against level descriptors and award levels accurately. In a few schools, leaders ensure that the whole-school monitoring of standards ties in with end-of-year processes and this allows many staff in key stage 2 to contribute to the process of scrutinising and awarding levels for pupils at the end of Year 6. However, in a few schools, leaders do not ensure that they have effective enough oversight of these processes and teachers' assessments of pupils in science are not as accurate. In addition, in a few schools, there is insufficient evidence to award the higher level 5.

111 Many teachers are generally confident about teaching science and have a good understanding of the subject. A few teachers remain less confident and lack enough subject knowledge to teach science well. In many cases, headteachers and science leaders ensure that they support staff, for example, by arranging in-school training sessions, or pairing less-confident with more-confident teachers. In the best cases, monitoring systems and detailed lesson observations help set the focus for staff training sessions.

112 There are too few opportunities for teachers to improve subject-specific science teaching. The availability of training opportunities in science through local consortia varies across Wales. As a result, school leaders are beginning to search for training opportunities from private providers. A few headteachers seek out expertise from other primary schools with recognised good practice to help their own schools.

113 Most schools have good resources for teaching science. While space is often at a premium, many schools devise creative ways of delivering practical investigations, such using school halls and outside areas. Many leaders monitor science resources carefully and allocate enough funds to buy additional equipment.

114 In Welsh-medium schools, there is often a shortage of high-quality, commercially produced Welsh-medium resources for science. Many teachers work hard to translate exiting material or produce their own resources. A few Welsh-medium primary schools also work with their local secondary schools to produce resources to deliver the curriculum.

115 Despite the national picture identifying a notable difference in outcomes between pupils eligible for free school meals and their peers, few leaders use the Welsh Government's pupil deprivation grant to support pupils in this subject.

Design and technology

116 In a minority of primary schools, leaders treat design and technology as an important curriculum subject and recognise its strength as a subject in which pupils can develop their thinking, problem-solving, literacy, numeracy and ICT skills.

117 Nearly all schools have an individual or team that takes responsibility for leading design and technology, either as a subject in its own right or as part of a group of complementary subjects. Most tend to monitor resources and help organise worthwhile events, such as entrepreneurial projects. As a result, they generally ensure that most pupils have interesting opportunities to develop skills and knowledge in a majority of the areas of design and technology. However, few undertake robust self-evaluation regularly enough, such as monitoring standards, curriculum time allocation, or the quality of teaching. As a result, too many schools do not ensure that pupils develop enough skills in this subject.

118 Many school leaders identify weaknesses in their provision for design and technology, such as a lack of specific resources or weak teacher knowledge or confidence, especially when dealing with 'systems and control'. However, leaders in only a very few schools develop suitable improvement plans to address these issues and the weaknesses often persist. Where schools have suitable plans for the design and technology curriculum, many leaders fail to identify when teachers do not implement these arrangements consistently.

119 Only a few schools provide staff with training in design and technology. While regional consortia provide very few opportunities for training in this subject, a few headteachers have organised training opportunities through private providers. For example, in Malpas Court Primary School, Newport, a number of staff undertook training on building and programming small machines and vehicles by a private

provider. These staff then trained others throughout the school. As a result, most teachers are now confident when delivering elements of the 'systems and control' portion of the design and technology curriculum.

120 A majority of schools have a curriculum leader or other member of staff who has a good understanding or useful experience in teaching design and technology. However, where expertise within a school does exist, a few leaders do not exploit this well enough and do not ensure that teachers always share knowledge and skills with colleagues.

121 A majority of schools have sufficient resources that allow them to deliver a majority of the areas of the design and technology curriculum. Many teachers supplement these usefully when needed. For example, they source ingredients that allow pupils to prepare and cook food, such as pizzas. However a minority of schools do not have the resources needed to deliver the 'systems and control' portion of the curriculum. Often, this is because leaders do not devote resources to an area of the curriculum that teachers do not cover due to their lack of confidence or lack of understanding.

Case study 5: Ysgol Gymunedol Llwyn yr Eos, Ceredigion – Developing pupils' life skills through design and technology

Information about the school

Ysgol Llwyn yr Eos is a community school on an integrated children's campus on the outskirts of Aberystwyth in Ceredigion. The school has 266 pupils aged 3 to11 in mainstream classes. It has four specialised units for pupils with complex and additional learning needs.

Around 25% of pupils are eligible for free school meals. This is above national figure. The school identifies about 40% of pupils as having additional learning needs, which is higher than the national average.

The local authority has two pupil referral units on the school site, one each for key stage 2 and key stage 4 pupils. The school maintains close links with the key stage 2 unit, offering its pupils daily opportunities for meaningful integration and inclusion.

Context and background to the practice

Staff at Llwyn yr Eos Primary School promote an ethos that prioritises the wellbeing of all members of the school community and celebrates diversity. Leaders have a strong community-based vision, with a focus on ensuring the best possible opportunities for all. They use design and technology projects and associated training to introduce the concept of lifelong learning and develop pupils' life skills.

Description of activity/strategy

Leaders plan activities that ensure that all pupils in Year 6 develop a variety of vocational and life skills on a weekly basis. To support this they have developed strong partnership with Hyfforddiant Ceredigion Training. This

group is part of Ceredigion County Council. It provides work-based learning in the local community, and delivers vocational training, educational and employability skills across a wide range of occupational areas.

With support from Hyfforddiant Ceredigion Training, all Year 6 pupils take part in a wide range of projects as part of a Junior Artisans Club scheme. They attend afternoon sessions at Hyfforddiant Ceredigion Training's base in Llanbadarn. Here they concentrate on gaining life skills through design and technology, including designing and making objects, such as creating a marble maze board game out of plywood. This encourages them to use their planning, designing, making and evaluating skills. Pupils develop these skills to a high level, for example when measuring to the nearest millimetre, and cutting and drilling competently.

These projects match well with the design and technology curriculum and provide training in the skills of cooking, gardening, carpentry, and first aid and resuscitation.

This innovative partnership helps to introduce vocational and life skills that pupils can continue to develop after they leave secondary school. The scheme is socially inclusive and rewarding. It has boosted pupil motivation and supported learners in taking on greater responsibilities for their learning and behaviour.

The skills embedded in the scheme reflect well the four key purposes identified in 'Successful Futures' (Donaldson, 2015).

Impact on provision and standards

As a result of participation in the scheme:

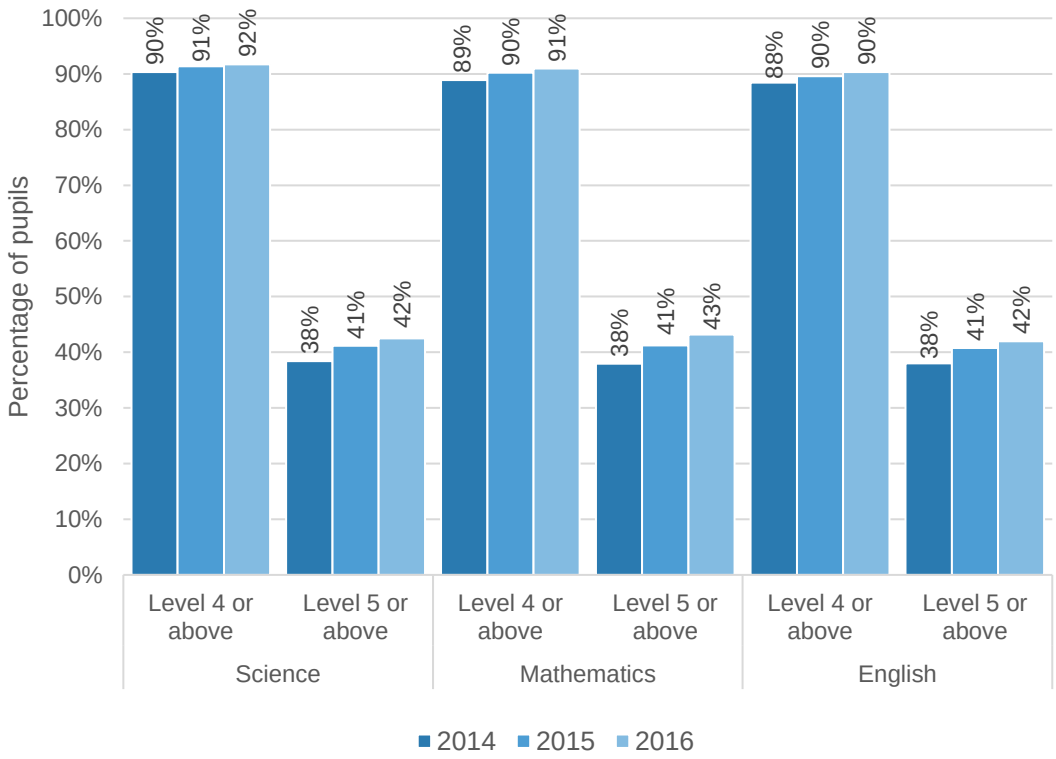
- There is an increase in pupils' self-confidence and self-esteem
- Many pupils' speaking and listening skills have improved
- There has been an improvement in behaviour, attendance and standards, including particularly the standards attained by boys

Appendix 1: Teacher assessment at key stage 2 in science

122 In 2016, 92% of pupils achieved the expected level 4 or above in science and 42% of pupils achieved the higher than expected level 5 and above. The percentage of pupils achieving these outcomes has increased year-on-year for at least the last five years.

123 More pupils achieve the expected level 4 in science than in English or mathematics. This has been a trend for at least the last five years.

Figure 1: Percentage of pupils achieving level 4 or 5 in science, mathematics and English key stage 2 teacher assessments, Wales, 2014 to 2016



124 Over the last five years, there has been a small but consistent gap of around four percentage points between the proportion of girls who achieved the expected level 4 compared with boys. Girls consistently perform better than boys.

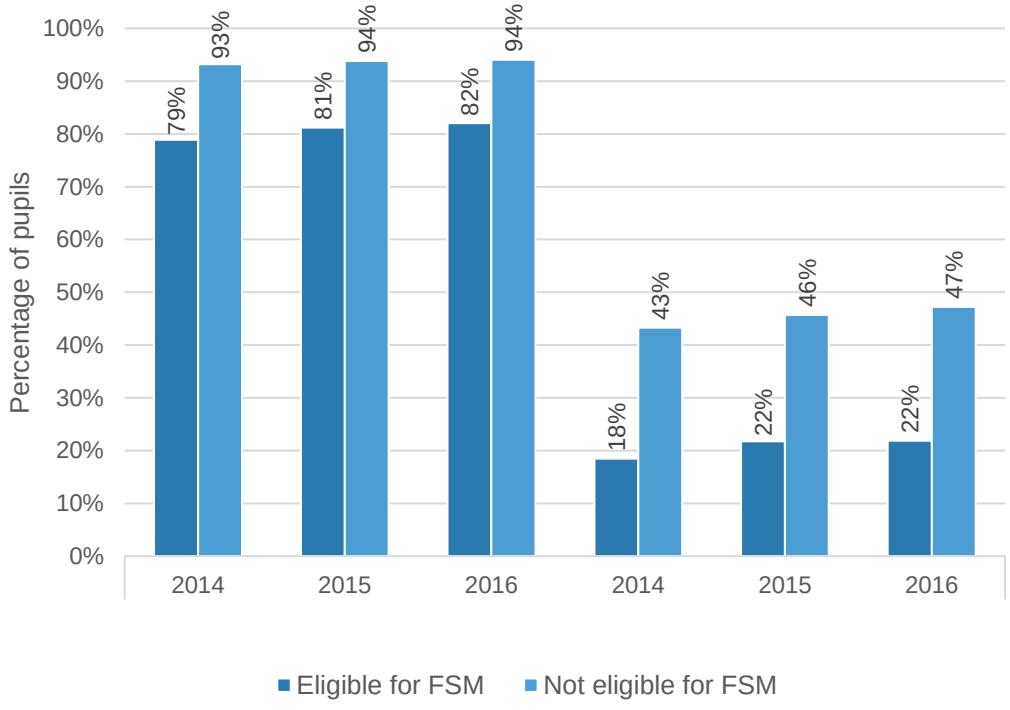
125 At level 5 and above, the gap between the achievement of boys and girls in science in 2016 is also around four percentage points. However, it is a gap that is growing slowly and one that has doubled in the last five years.

Figure 2: Percentage of pupils[1] achieving each level in science in key stage 2 teacher assessments by gender, Wales, 2012 to 2016

		All pupils	Girls	Boys
Level 4 or above	2012	89%	91%	87%
	2013	90%	92%	88%
	2014	90%	92%	88%
	2015	91%	93%	90%
	2016	92%	94%	90%
Level 5 or above	2012	33%	34%	32%
	2013	36%	37%	35%
	2014	38%	40%	37%
	2015	41%	43%	39%
	2016	42%	44%	41%

[1]Percentages rounded to whole numbers so there may be apparent differences between the gaps shown here and in text – gaps quotes are based on unrounded figures.

Figure 3: Percentage achieving each level in key stage 2 science teacher assessments by free-school-meal eligibility, 2014 to 2016



126 While the performance of pupils who are eligible for free school meals at both the expected and higher levels has improved over the last five years, the performance of their peers has also improved. This means that, at the expected level, the gap between pupils eligible for free school meals and their peers has decreased, but at the higher level the performance gap has increased.

127 In 2016, there was a 12 percentage point difference between the proportion of pupils eligible for free school meals who achieved the expected level 4 and above and their peers. At level 5 and above, in 2012 the difference in performance stood at around 21 percentage points. By 2016, the gap had increased to over 25 percentage points.

128 In schools with a higher percentage of pupils eligible for free school meals, substantially fewer pupils achieve the expected or higher level compared with those in schools with a lower percentage of pupils eligible for free school meals.

129 In 2016, in schools with fewer than 8% of pupils eligible for free school meals, over 97% of pupils achieved the expected level 4 and above. However, in schools with over 32% of pupils eligible for free school meals only 86% of pupils achieved that level.

Figure 4: Percentage achieving level 4 or 5 in key stage 2 teacher assessments by FSM band (three year average), 2012-2016

FSM band	Level 4 or above					Level 5 or above				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Up to 8%	95%	96%	96%	97%	97%	44%	49%	50%	54%	54%
Between 8% and 16%	93%	94%	94%	95%	96%	37%	39%	43%	45%	47%
Between 16% and 24%	89%	91%	92%	93%	92%	32%	34%	37%	41%	41%
Between 24% and 32%	87%	89%	89%	90%	91%	28%	32%	33%	34%	36%
Over 32%	81%	83%	84%	85%	86%	22%	27%	28%	30%	32%

130 This gap in performance between these groups has reduced in the last five years and currently stands at just under 11 percentage points. However, this is still too high.

131 The difference at level 5 and above is even greater. In 2016, in schools with fewer than 8% of pupils eligible for free school meals, 54% of pupils achieved level 5 and above. However, in schools with over 32% of pupils eligible for free school meals, only 32% of pupils achieved that level. This is a difference of 22 percentage points.

132 Despite the focus on improving outcomes for pupils at risk due to poverty, this performance gap at the higher level has not decreased over the last five years.

Appendix 2: Questions for self-evaluation

133 As a starting point for reviewing current practice in science and design and technology, schools can use the following questions as part of their self-evaluation processes:

Standards

1 Do leaders and teachers know the standards pupils are achieving in science and in design and technology across the school?
2 Have we analysed the performance of different groups of learners carefully and over time? What messages does this analysis give and are we acting on findings robustly?
3 Do we have high expectations of all learners, including the more able?
4 Do we ensure that all pupils have opportunities to learn about all areas of the design and technology curriculum?

Provision

5 Do we ensure all teachers are planning learning in science lessons that challenges all pupils at an appropriate level, particularly the more able?
6 Do we have detailed plans to develop pupils' subject knowledge, understanding and skills in science and in design and technology?
7 Do we use science and design and technology as effective areas to develop pupils' literacy, numeracy, ICT and thinking skills?
8 Are teachers encouraged to be innovative in their planning?

For example:

- Do teachers relate pupils' learning to their local context whenever possible?
- Are the topics taught and examples used relevant and current?
- Is teaching responsive and flexible? Do teachers respond to local, national or global issues including those that relate to the environment?
- Do pupils have opportunities to develop their work or ideas for a real-life context, developing the value of their work?
- Do teachers use technology creatively to support learning such as video-conferencing or virtual learning platforms?

9 Do we offer pupils engaging and relevant enrichment experiences related to science and design and technology, to broaden their understanding?

For example:

- visits to places of interest, or visitors to school, that provide pupils with practical or real life experiences

Leadership

10 Do we have a clearly understood rationale for the way we plan and deliver our science and design and technology curriculum?
11 Does our monitoring and evaluation of science and design and technology focus robustly on pupils' skills and knowledge, and on the quality of teaching?
12 Have we evaluated our current curriculum to plan for developing the new area of learning and experience?
13 Do we analyse teachers' performance and provide them with appropriate training and support in the areas of science and of design and technology where they lack confidence or understanding?
14 Do we use our pupil deprivation grant effectively to reduce gaps in performance and ensure equality of access for disadvantaged learners?

Appendix 3: Evidence base

The findings and recommendations in this report draw on the analysis of primary school inspections over the last three years and an analysis of end of key stage 2 data for the last five years. This evidence was supported by visits to 20 primary schools and telephone interviews with a further six schools. Estyn identified the schools at random; ensuring that inspectors visited a range based on size, geographical location, proportion of pupils eligible for free school meals, language of instruction and religious characteristic.

During their visits, inspectors:

- observed science and design and technology lessons in key stage 2
- scrutinised pupils' work in both subjects
- met representative groups of pupils
- reviewed curriculum plans and documentation
- interviewed teachers and school leaders

Estyn would like to thank the following schools that supported this thematic review:

- Ysgol Goronwy Owen, Isle of Anglesey
- Ysgol Penybryn, Gwynedd
- Ysgol Gymunedol Llwyn-yr-Eos, Ceredigion
- Ysgol Y Llys, Denbighshire
- Victoria Primary School, Wrexham
- Penycae Community Primary School, Wrexham
- Ysgol Deganwy, Conwy
- Ysgol Gynradd Gymraeg Castellau, Rhondda Cynon Taf
- *Ysgol Gynradd Gymraeg Castell-nedd, Neath Port Talbot
- Ysgol Gynradd Bryn Sierfel, Carmarthenshire
- *Ysgol Gynradd Gymraeg Cwm Gwyddon, Caerphilly
- Gorseinon Primary School, Swansea
- Ysgol Gynradd Dyffryn Trannon, Powys
- Dinas Powys Primary School, The Vale of Glamorgan
- Tondu Primary School, Bridgend
- Penygawsi Primary School, Rhondda Cynon Taf
- Crumlin High Level Primary, Caerphilly
- St Patrick's Roman Catholic Primary School, Cardiff
- Rhydyfro Primary School, Neath Port Talbot
- Abernant County Primary School, Rhondda Cynon Taf
- St Mary's Roman Catholic Primary School, Cardiff
- Llanyrafon Primary School, Torfaen
- *Malpas Court Primary School, Newport
- St. Illtyds Roman Catholic Primary School, Merthyr Tydfil
- Fenton Community Primary School, Pembrokeshire
- Cwmrhydyceirw Primary School, Swansea

* Curriculum Pioneer School. See Glossary

Glossary

Curriculum Pioneer School	Schools that are currently working with the Welsh Government and other curriculum pioneer schools to develop and to pilot a new curriculum for Wales
Four Core Purposes	Successful Futures (Donaldson, 2015) sets out the need for common purposes that permeate the curriculum and promote high aspirations and a determination to achieve. These four core purposes are, that children and young people develop as: • ambitious, capable learners, ready to learn throughout their lives • enterprising, creative contributors, ready to play a full part in life and work • ethical, informed citizens of Wales and the world • healthy, confident individuals, ready to lead fulfilling lives as valued members of society
Hwb	The Welsh Government's bilingual digital learning platform, designed to allow all pupils and teachers in Wales greater access to online resources. It allows users to access and share information and is accessible from any internet-enabled device.
STEM	Science, Technology, Engineering and Mathematics

Numbers – quantities and proportions

nearly all =	with very few exceptions
most =	90% or more
many =	70% or more
a majority =	over 60%
half =	50%
around half =	close to 50%
a minority =	below 40%
few =	below 20%
very few =	less than 10%

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