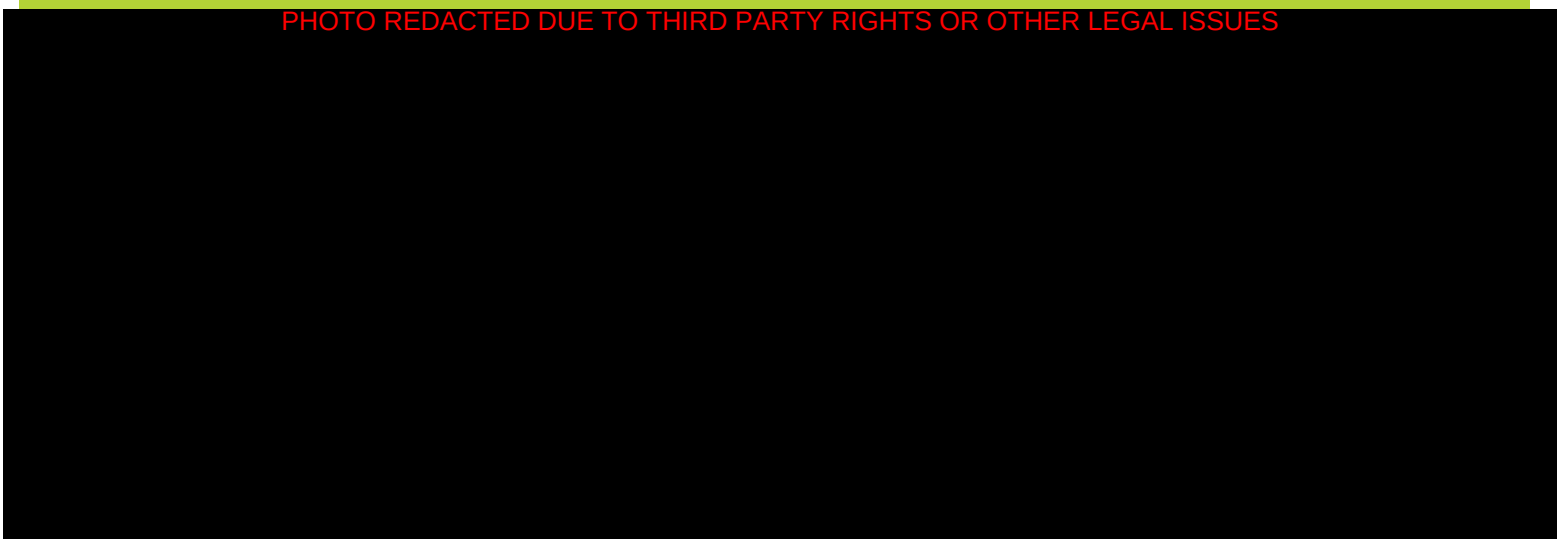
Education Scotland
Foghlam Alba

The Sciences 3-18

September 2013 Update



Transforming lives through learning

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[1] Where the term 'sciences' is used this refers to what children and young people experience in pre-school centres, primary schools, special schools and all the sciences in S1-S6 including Skills for Work courses, biology, chemistry, physics, science, human biology, biotechnology, and managing environmental resources (MER).

[2] Where the term 'school' is used this refers to pre-school centres, primary, secondary and special schools.

[3] Where the term 'staff' is used this refers to all practitioners including early years workers and teachers.

Introduction

This report is the first updated version of the 3-18 Sciences Impact report originally published in September 2012 which evaluated current practice in the sciences. It identifies good practice, highlights important areas for discussion and further development and signposts useful resources. These resources include video clips listed in Appendix 2 which describe good practice in some of the aspects for development outlined in the 2012 report. The report comes at a time when Scottish schools are continuing to implement Curriculum for Excellence and the findings reflect this changing landscape. Education Scotland will continue to support these changes and share emerging innovative and thought-provoking practice as part of its contribution to a **national professional learning community**. It is intended that this web-based report will continue to act as a hub for ongoing professional dialogue and development. Practitioners are encouraged to become engaged with each other and with Education Scotland staff to share practice and address areas requiring development via CPD Central. We are continuing to work with children, young people, parents[4] and the wider sciences community to identify how all can engage in taking forward this report's key messages. At the time of publication of this updated report Education Scotland had hosted three national sciences conversation days.

The report is one of a series designed to gauge the **impact** of a changing curriculum on learners' experiences and achievements. The focused visits in 2011 and 2012 which formed a significant part of the evidence base were designed to maximise support for ongoing improvements. Professional dialogue was built around the school's own evaluation of progress in the sciences. The dialogue was enhanced by the findings from observations of learning and teaching, discussions with children and young people, staff, curriculum managers and local partners and stakeholders as appropriate. In providing a broad overview of emerging strengths and aspects for further development, the report builds on the messages of: *Science: A Portrait of current practice in Scottish Schools (2008), Improving Scottish Education: A report by HMIE on inspection and review 2005 -2008 (2009)* and *Quality and improvement in Scottish education: Trends in inspection findings 2008-2011 (Education Scotland, 2012).*

It is important that practitioners consider this report's messages along with other key documents such as the *Sciences Principles and Practice (2009)* paper as they move forward with Curriculum for Excellence. The *Sciences Principles and Practice (2009)* paper sets out the purposes of learning within the sciences. It also describes how the experiences and outcomes are organised, and provides guidance on aspects such as learning and teaching, broad features of assessment, progression and connections with other areas of the curriculum. It outlines an **ambitious agenda** for staff and the entitlements of all children and young people in the sciences. This report therefore is broadly structured around the themes in the *Sciences Principles and Practice (2009)* paper to assist staff as they develop their **thinking** and **practice.**

[4] Where the term 'parents' is used this should be taken to include foster carers, residential staff and carers who are relatives or friends.

Evidence for this report came from the following sources:

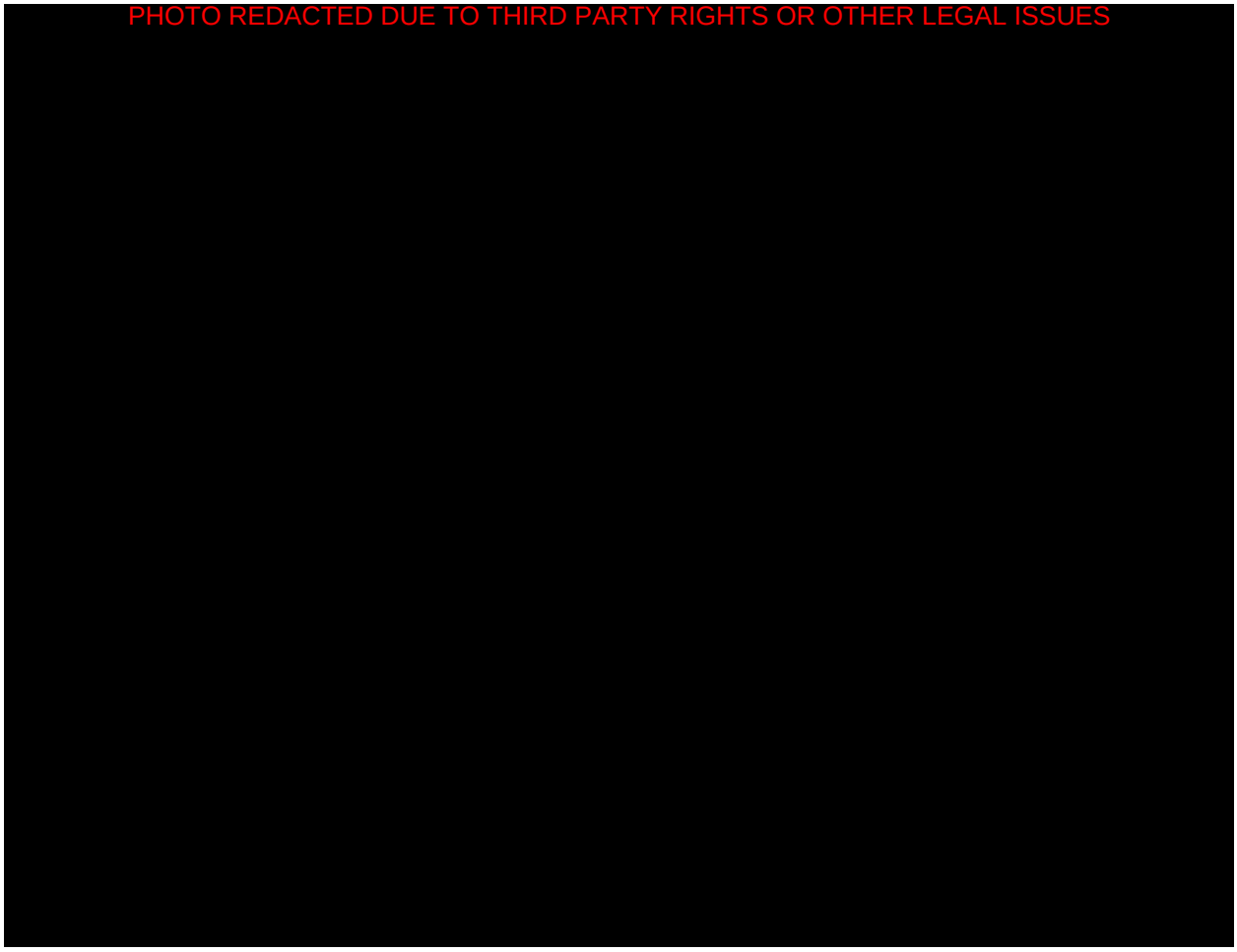
- A series of focused inspection visits to a number of pre-school centres, primary, secondary and special schools during the period April 2011 to April 2012. A list of educational establishments visited for this report is in Appendix 1.

- Analysis of relevant evidence from general inspections and other professional engagement visits carried out over the past three years.

- Analysis of the patterns of uptake and performance by school students in the sciences in SQA examinations. Statistical data is contained in Appendix 4.

- A review of relevant literature to take account of key messages pertinent to the sciences.

- Engagement in professional dialogue with practitioners, specialists across Education Scotland and members of the scientific community from within and outwith schools.



Context

'*Science is an important part of our heritage and we use its applications every day in our lives at work, at leisure and in the home. Science and the application of science are central to our economic future and to our health and wellbeing as individuals and as a society. Scotland has a long tradition of scientific discovery, of innovation in the application of scientific discovery, and of the application of science in the protection and enhancement of the natural and built environment*'.

Sciences Principles and Practice (2009)

The Scottish Government regards the sciences as vital for **Scotland's future** and its **economic growth**. Indeed, it has identified Energy and Life Sciences as two of six 'key sectors' having 'high-growth potential and the capacity to boost productivity' - *the Government Economic Strategy, 2007*. In 2008, the Scottish Government produced a *strategic framework for science* which stated that

'*the impact and importance of science,…looks set to increase further, with basic and applied science being key to addressing society's major concerns including climate change, sustainable energy and life-threatening disease… As such the provision of future scientists is crucial to Scotland's success and merits considerable attention'*.

The importance of science has been reinforced further by Michael Russell, Cabinet Secretary for Education and Lifelong Learning. At the launch of *Science & Engineering 21 – An Action Plan for Education (2010)* he stated that

'*Science and engineering are the cornerstones of a successful, sustainable economy and one of the keys to Scotland's future. It is essential that our children and young people understand the importance of science and engineering, both for the development of the skills for learning, life and work that they will need, and for the contribution science and engineering make to the world we live in'.*

Statistics indicate that the Scottish education system is successfully encouraging the uptake of science subjects at the middle and upper stages of secondary school. Currently statistical evidence shows the continued popularity of science subjects, with chemistry, biology and physics featuring consistently in the six most popular subjects studied at Higher level. National and international measures of Scottish learners' attainment as reported in the *2007 Scottish Survey of Achievement (SSA) Science, Science Literacy and Core Skills*, *Trends in International Maths and Science Study (TIMSS)* and the *Programme for International Student Assessment (PISA) 2009,* confirm important strengths but also identify aspects of learning in which children and young people could do better.

There is evidence of much good practice in sciences education in Scotland but there is also room for improvement. This report which sets out key strengths and areas for development, combined with the good practice examples and web links, promotes the means by which staff can create bespoke action plans to deliver the highest quality science education.

Curriculum

Building the Curriculum 3 (2008) defines the curriculum as the ***'totality of experiences'*** *which are planned for children and young people throughout their education, wherever they are being educated'*. These experiences can be planned across the following aspects: the ethos and life of the school, curriculum areas and subjects, interdisciplinary learning, and opportunities for personal achievement.

Increasingly, staff are recognising the significance of planning learning in the sciences which takes account of each of these four aspects of the curriculum. Many schools are providing a range of opportunities for children and young people to develop relevant sciences knowledge and skills outwith the timetabled curriculum. This is particularly notable in the many examples of eco work undertaken in schools across all sectors. Eco work in schools engages children and young people in key issues, including the environment, sustainability, global citizenship and the value of a low carbon future. Over 98% of Scotland's local authority schools, many independent schools and early years establishments currently participate in the Eco-Schools Scotland programme.

Secondary schools organise relevant work experience placements for young people and promote participation in science-based events and challenges such as Go4Set and Opito's Petrochallenge. Although an improving picture, there is scope for more secondary science teachers to plan learning which takes better account of aspects such as the ethos and life of the school and offers increased opportunities for personal achievement.

Good Practice Example 1

Primary schools working together across a cluster organised a residential experience focusing on outdoor learning for P7 children. The children developed their knowledge of conservation through working in the outdoor environment. Their learning was recognised through achievement of a John Muir Award.

Good Practice Example 2

Some schools have made use of the Youth Scotland partnership with Eco-Schools Scotland. This has allowed learners to gain individual recognition and accreditation for their learning through involvement in the Eco-Schools Scotland programme, using external moderation by Youth Scotland and accreditation by the Awards Scheme Development and Accreditation Network (ASDAN).

For further information on youth awards in Scotland, access Amazing Things (Third Edition)

Good Practice Example 3

The Go4Set challenge has been used by a number of schools, sometimes in conjunction with the CREST Award scheme, to recognise achievement in sciences. One school reported an impact on young people's development of enterprising attitudes in the context of sustainable development, as a result of participation in the challenge and the opportunity to work alongside industrial mentors.

Staff across all sectors recognise their responsibility to develop learners' **literacy, numeracy and health and wellbeing**. Increasingly, staff are taking these areas into account when planning programmes in the sciences. In all sectors, care needs to be taken to ensure progression and an appropriate level of challenge are taken into account when planning learning. In some pre-school centres, literacy, numeracy and health and wellbeing are not well embedded into real-life contexts in the sciences. Across all sectors, some schools lack an overall strategy for the development of literacy, numeracy and health and wellbeing. As a result, staff are unclear about how best to plan for the development and application of literacy, numeracy and health and wellbeing within learning in the sciences.

Good Practice Example 4

In a primary school, children used a webcam and a motion sensor to monitor the variety and quantity of birds that visited wildlife boxes in the school grounds, over a period of time. The children used and developed numeracy skills as they gathered, analysed and presented data in an appropriate manner. They compared and contrasted evidence gathered across the school session to discuss and learn how living things are affected and respond to changes in climate across the year.

Good Practice Example 5

A writing frame was developed and adopted by primary and secondary staff from across all curriculum areas and from within a cluster. Children and young people use this writing frame to help them to structure their functional and creative writing in all of their subjects. The writing frame is displayed prominently in all learning areas and referenced consistently by staff across the schools. Children and young people found this helped them to understand how to develop and apply literacy skills in different contexts, including writing to communicate understanding and appropriate presentation of scientific findings and reports.

Good Practice Example 6

Non-promoted staff from five different primary schools and their associated secondary school formed an effective partnership to improve children's literacy skills in the sciences. They met regularly, undertook reciprocal visits to observe learning and teaching, moderated children's work and reviewed plans. Working collaboratively they successfully developed a coherent and progressive approach with measureable positive impact on children's literacy skills. Expectations of children's capabilities in both sectors has increased. Children now achieve much higher standards in report writing with notable improvements in their use of scientific terminology and vocabulary. Children write independently and use higher order thinking better when forming conclusions and evaluations of investigations.

Good Practice Example 7

A secondary school used a whole school approach to developing young people's numeracy skills. A numeracy working group agreed the way that aspects of numeracy would be approached across the school. Approaches were summarised in a helpful 'Pupil Numeracy Guide' that young people used for support across their subjects. For example, 'The story of graphs' approach was used to aid learners in interpreting data presented graphically in the sciences. Copies of the numeracy guide were issued to parents to enable them to support their children's learning.

How are the sciences experiences and outcomes being organised within the broad general education?

Schools are expected to ensure that all children and young people have opportunities to experience, as part of their broad general education, all the experiences and outcomes, across all curriculum areas, up to and including the third curriculum level. These should be experienced by all learners, as far as this is consistent with their learning needs and prior achievements. Many staff are using the *Principles and Practice (2009)* papers as an overview of what learning in the sciences should look like and what it should **enable the learner** to do. Staff from early years through to the secondary stages are becoming more familiar, and increasingly gaining confidence in working with, the *sciences experiences and outcomes (2009)* as they use them to develop new learning programmes. However, too many teachers across all sectors are still unaware of the *Sciences: Concept development in the sciences (2009)* paper which should be used in tandem with the *sciences experiences and outcomes (2009).* At times, staff are micro-managing the curriculum, breaking experiences and outcomes down to very fine and specific detail. This results in a cluttering of the curriculum, and often a mechanistic approach to learning and teaching. The effect is to hamper staff from focusing on the broader aim of achieving what it is that learning in the sciences should enable a learner to do.

The flexible nature of the broad general education phase gives staff tremendous scope to apply their professional skills, knowledge and creativity to deliver varied, rich

and rewarding educational experiences designed for and appropriate to their children and young people in the local context. Consequently, across the country, there are a variety of ways in which children and young people are experiencing the sciences within their broad general education.

In pre-school centres, children experience activities through play, investigation and discussion which is often built around their interests and which naturally stimulates their curiosity. In primary schools, children can experience the sciences through a discrete, interdisciplinary or blended approach.

In secondary schools, young people can study the sciences through discrete subjects, integrated sciences, interdisciplinary learning or a blend of these. Secondary schools are increasingly developing innovative approaches to ensure young people achieve their entitlement to a broad general education. These include:

- well-planned interdisciplinary learning which combines experiences and outcomes from different subjects and curriculum areas applied in motivating and relevant contexts;

- a modular based system in S2 and S3 allowing young people to build their own learning programme, consolidating learning whilst increasing depth and applying learning in new contexts;

- providing opportunities for personalisation and choice with young people able to select electives such as 'forensic science' or 'the study of stars and planets'. Study through science electives can develop talents and interests, provide greater depth of study and enhance skills development. It can also provide opportunities for personal achievement, with accreditation through external awards such as the CREST Awards;

- providing specialisation and personalisation through 'masterclasses' for part of the year in S2, planned in addition to opportunities to experience all third level experience and outcomes, and progress to fourth level outcomes as appropriate; and

- providing choice, breadth and challenge through opportunities to select areas for specialist study by 'majoring' in one subject such as physics, chemistry or biology, while continuing with some more limited studies in the other subjects in the same curriculum area.

In most special schools and units, staff are planning children and young people's learning on a personalised basis linked to their individual needs. Often, the sciences are being planned in a holistic way as part of skills for life programmes, for example through topics such as 'myself' or 'caring for the environment'. Where appropriate, children and young people from special schools are benefiting from undertaking some of their learning with their peers in mainstream schools. There is scope to improve partnership working between mainstream and special schools to help ensure that children and young people can access a broad general education.

How are schools planning and delivering the sciences in the senior phase?

Secondary schools have planned and are continuing to review the shape of the curriculum in the senior phase. Teachers are becoming increasingly familiar with the details of the new national qualifications in their own subject areas and are continuing to plan learning and teaching in the senior phase. As a result, many staff feel that they are in a better position to plan and shape young people's learning at the broad general education phase to provide a sound basis for more advanced study in the senior phase. *Curriculum for Excellence Briefings* *6,7,8* and *11* provide advice and guidance for practitioners. Reference to the relevant SCQF guidance and the *Curriculum for Excellence Briefing 1 (2012)* on this topic could support teachers in developing a clearer understanding of notional hours. Not all teachers yet appreciate that learning at the third and fourth curriculum levels during the broad general education should be preparing young people for this progression, and that learning in the senior phase which leads to qualifications, must build on that experienced in the broad general education.

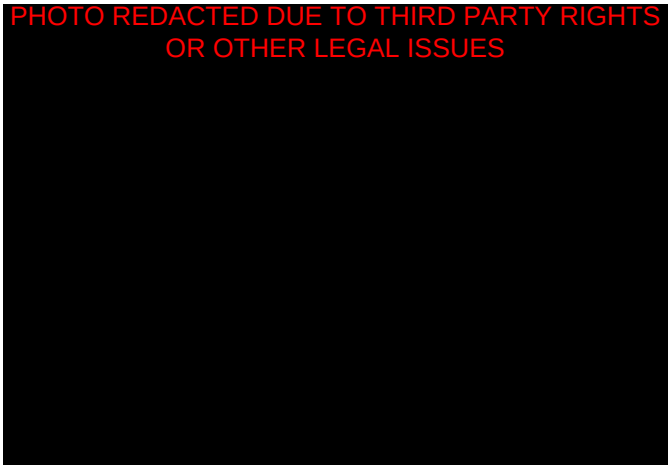
Currently, the sciences are well represented in the senior phase and there is a high uptake of these subjects at national level (Appendix 4 contains statistical information). Most secondary schools offer opportunities to study a broad range of subjects at different levels to meet young people's needs. They provide progressive pathways for young people as they progress through school. Such pathways can include opportunity to study a range of Skills for Work courses such as rural skills or laboratory skills through to Advanced Highers and the Scottish Baccalaureate in Science. The subjects on offer by science departments in recent times has ranged from the most common examples of biology, physics and chemistry to human biology, rural skills, managing environmental resources and biotechnology. All schools sampled provide opportunities for young people to study two discrete sciences concurrently in the senior phase, with some offering the opportunity to study three. A few schools are finding it difficult to offer as broad a range of courses in the sciences as they would have liked to due to issues such as staffing. Some have found innovative ways around this such as taking advantage of consortium arrangements and working with partners such as colleges and universities. In a few schools, there have been issues around progression with Intermediate 1 and Intermediate 2 courses not always being offered in specific subject areas.

Care must be taken to ensure that every young person's prior learning is taken fully into account when providing advice and guidance for subject choices. A few young people who did not achieve awards in the courses they studied at S5 and S6, or who did not manage to complete their science course(s), clearly did not have appropriate prior learning to access learning successfully at the level they were studying.

Although numbers are small, special schools or units are increasing the range of awards and qualifications they are using to recognise achievement. Some offer Access 1 or 2 science, Access 3 biology, physics or chemistry or individual or a combination of units from such courses. A few offer opportunities to achieve qualifications at more advanced levels when appropriate to meet the needs of individual learners. Increasingly, environmental issues are being studied as part of personal development courses. There is much scope to extend the use of the sciences subject qualifications within the special school sector.

Good Practice Example 8

One secondary school provides support and education for young people with autistic spectrum disorders mainly in an Enhanced Provision Unit within the school. The unit aims to help young people access the curriculum as independently as possible. Some young people's needs are met through a high proportion of their learning being within mainstream classes with independence. Others can access some classes with individualised support, whilst young people with more complex needs access very few mainstream classes and learn in the unit for a higher proportion of their time. When learning in the unit, a member of staff will interpret any crucial concepts that the learner finds difficult to understand and consolidate what has been learned in class. This is usually done by making the information more visual through use of the internet or interactive whiteboards, through staff-developed visuals, or by finding relevant real-life examples to help facilitate understanding. Sciences staff provide effective support to unit staff in the development of individualised learning programmes. Through successful approaches to meeting young people's needs a few young people learning in the unit have successfully achieved Standard Grade and Access sciences awards and units.



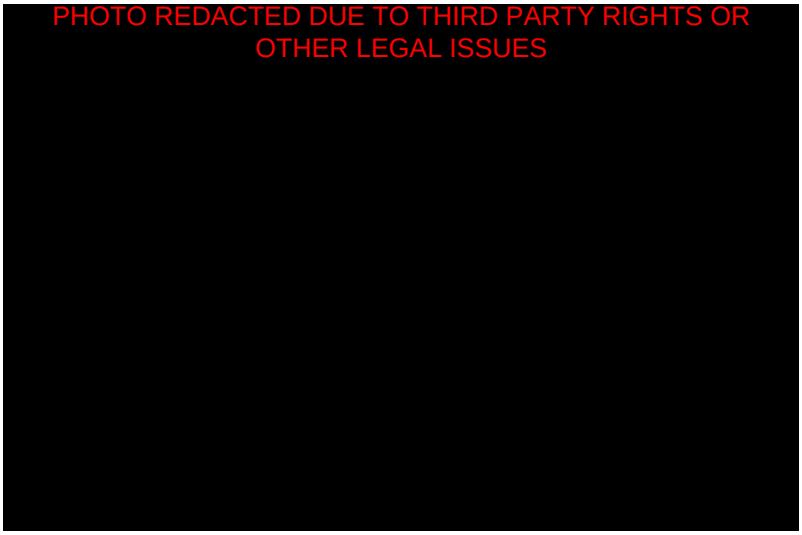
Good Practice Example 9

One secondary school provides support for young people with complex needs in a learning base within the school. They experience their learning in the sciences in mixed stages mainly within the base. Shared experiences with those in the mainstream school supports their learning, such as activities related to the school's 'Managing an Environment Area'. The base works very closely with external partners from recycling and forestry projects to involve young people in teamworking and enterprise activities. A local dietician has supported the health and wellbeing programme with links to science work. There has been measurable positive impact on a few young people's health and wellbeing. Sciences staff effectively support the sciences provision through supporting the development of learning programmes and securing appropriate resources. Close partnership working has enabled young people educated within the base to achieve qualifications.

What connections are made within and beyond the sciences?

Across all sectors, interdisciplinary learning is an increasing feature of learning in the sciences at the broad general education phase. There are many examples of well-judged, well-planned and innovative interdisciplinary learning. In the best examples, learning is providing opportunities for children and young people to experience deeper, more enjoyable and active learning. As a result of such learning, children and young people are able to recognise the connectivity which exists between the sciences and other curriculum areas such as social subjects, mathematics and technologies. At the outset, staff need to ensure that interdisciplinary learning is planned with a clear focus on outcomes for children and young people. Staff are often unclear about how they will assess progress in developing knowledge and skills that are acquired in an interdisciplinary context.

Most of the young people at the upper stages of secondary school who had undertaken the interdisciplinary project for the Scottish Baccalaureate in Science, found this a beneficial experience. They described a positive impact on their confidence as they took on more responsibility and linked with external partners, their development of scientific literacy, their interests in the sciences and their heightened career awareness.



Good Practice Example 10

A partnership between the English and sciences departments in one school strengthened learning through topical debates in the sciences. Staff reported greater understanding of assessment criteria and approaches to appropriate assessment of learners' participation in and contribution to topical debate. Young people found that they were more able to connect their learning in English to learning in the sciences, and to express their understanding of aspects of the sciences using debate. Researching new contexts to contribute fully to debates, with clear understanding of criteria for assessment, has led to deeper learning for young people.

Good Practice 11 – New to this updated version of the report

An innovative approach to learning in S3 has been developed by one school. Led by a teacher in the sciences, the initiative involved health and food technology, English, religious, moral and philosophical studies (RMPS) and modern studies teachers collaborating in the planning of interdisciplinary learning. A "Lost" theme was chosen as a context for learning. Young people found the storyline approach to their learning stimulating. The story was developed first in biology with other departments using the context for learning at appropriate points throughout the session. Teachers planned together before the project began with clear outcomes for young people being identified. Teachers' planning focused on subject -specific experiences and outcomes at fourth level, the development of young people's literacy, numeracy and health and wellbeing and a range of skills. Across the year young people could engage with the characters in the story through a blog-style approach hosted on the school website. Young people debated ethical and moral issues in RMPS and modern studies in topics that they had suggested. They regularly evaluated their own and others' listening and talking skills through debate. There were significant opportunities for creativity, applying learning in unfamiliar contexts, and communicating understanding through a range of media. Young people evaluated the project. They enjoyed the project, felt motivated, found that they could see links in their learning across subjects, felt that their learning was relevant and found that their confidence in presenting to others was developed. The school has used young people's views to make changes to the project. Teachers have found that there needs to be a more explicit focus on dialogue with young people to make it more explicit the skills that they are developing. Young people's language of skills development needed developed better. This has informed the planning for the next interdisciplinary project.

Good Practice Example 12

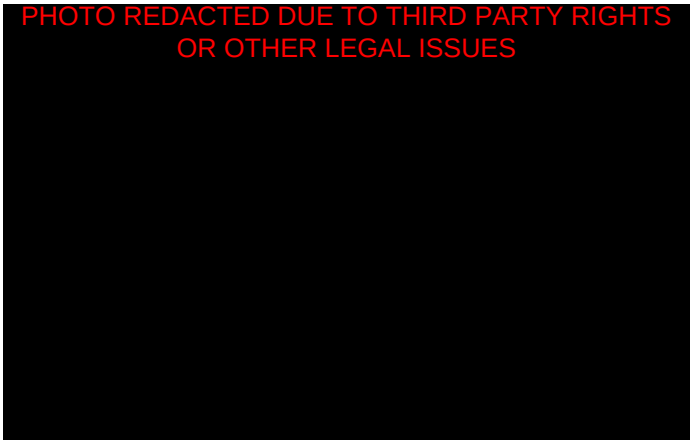
A number of schools are working in partnership with colleges and universities to enrich learning for young people studying for the Scottish Baccalaureate in Science. This allows opportunity for young people to pursue interdisciplinary project work based in their interests. Young people report high levels of motivation associated with the Scottish Baccalaureate and feel better prepared for transitions to sustainable positive destinations as a result. They enjoy opportunities to work in the college environment, and to work with young people from other schools, and benefit from independent responsibility for their learning and achievement.

Schools are generally linking with a range of partners to support and enhance learning in the sciences. There are numerous external partners who support learning in the sciences across Scotland including the four national science centres, STEM ambassadors, local businesses, local colleges and universities, and parents. Schools generally use excursions, visitors and outdoor learning well to support and enhance learning. Examples include: children in a nursery class visiting an observatory to enhance their Space topic; ZooLab visiting a nursery class as part of their animals topic or children and young people in a special school visiting a local garden centre linked to a bulb planting aspect of their plants topic. There is a need for schools to ensure that visits are focused and appropriately timed, planning jointly with partners to add as much value to outcomes for learners as possible. Increasingly, external partners are linking what they can offer to experiences and outcomes to help schools plan better for visits to provide more coherent, relevant and meaningful learning.

Young people often report feeling that they generally receive high-quality careers guidance to support them in preparing for and following a career path in the sciences. Visiting speakers from further and higher education and open days to colleges and universities raise aspirations and promote careers in the sciences. A number of strong links exist with colleges and universities whose staff provide valued support for young people to complete qualifications such as Skills for Work courses, their investigations at Advanced Higher or the interdisciplinary project for the Scottish Baccalaureate in Science. Schools also support young people to achieve sponsorship such as the Nuffield Award which provides work experience and an insight into careers in the sciences.

Good Practice Example 13 - New to this updated version of the report

In framing learning within an earth sciences context, one school made use of the GeoBus programme run by St Andrew's University. Young people studying physics and geography were introduced to specialist equipment including infrared cameras, accelerometers and also radar scanners which are used to map the formation of lava domes prior to volcanic eruptions. This set the learning in a vocational context with young people being more aware of possible future careers. The school visit included a capacity-building field trip for school practitioners to identify local geological features which could be used to support future field studies activities organised by the school.



Good Practice Example 14

In one primary school, children benefited from high-quality learning in the sciences which increased engagement and improved motivation. Staff worked together with the local science centre to plan learning in the sciences. Staff felt that they benefited from the professional learning opportunities and access to equipment, materials, ideas and support available through close partnership with the science centre. Children enjoyed the additional opportunities for hands-on science and access to equipment that they would not normally have experienced.

Good Practice Example 15

One primary school organises an annual 'science week' in the summer term. This is planned over the school session involving children, teachers, parents and external partners. The activities, visitors and guest speakers are selected by each class to complement and provide depth to their ongoing learning in the sciences. For example, children's selections have included 'Animal Man', the Royal Society for Prevention of Cruelty to Animals (RSPCA), the school nurse, dental hygienist and one of the science centres to provide workshops for them. In addition, a number of parents in science-related careers were invited to talk to children about their jobs to help raise the profile of careers in the sciences. The children evaluate each session and use this to plan the next 'science week'. Children describe being enthused by inspiring activities, workshops and access to resources that they would not routinely have access to in their everyday school life.

Good Practice Example 16

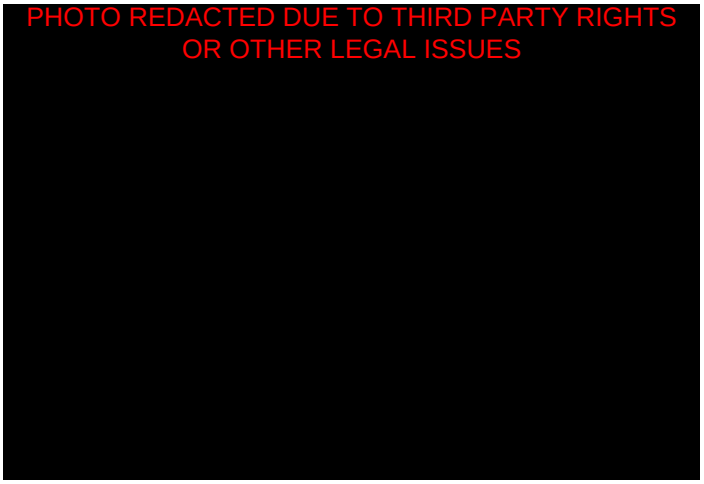
One school has been given a substantial area of land by a local business to maintain, develop and use as an 'outdoor classroom'. This provides a relevant context for learning. Teachers can take classes to this outdoor area and develop young people's knowledge and skills as they study areas of the sciences such as biodiversity and sustainability. Young people's skills are developing through using sampling techniques, making various measurements, recording, presenting and analysing data. They develop team working skills as they contribute ideas for improving the land and work together to carry out practical work such as planting trees.

Designing the curriculum: a tool for discussion

When planning learning for children and young people from 3 to 18, many staff are aware of the seven **principles of curriculum design,** namely challenge and enjoyment, breadth, progression, depth, personalisation and choice, coherence and relevance. There is much variation in the efficacy of planning for effective learning and teaching using these design principles. More staff, as they continue to develop the curriculum, should review their practice against the principles of curriculum design. The following consideration of each principle outlines a few emerging strengths and areas for further development. Most of the examples given here refer to the planning of learning in the broad general education. The seven principles of curriculum design also apply to planning learning in the senior phase.

Challenge and enjoyment

Children and young people often enjoy exciting, stimulating and enjoyable experiences which are sustaining their motivation and developing their interest in the sciences. This is particularly true where staff have planned active and/or experiential learning. Young people at S1 and S2 frequently report enjoying practical work which they have experienced in their learning in the sciences. At times, across all sectors, planned learning does not provide sufficient challenge for all learners. Care should be taken to ensure that learning is both enjoyable and sufficiently challenging to develop knowledge and skills. In the best examples, staff plan activities to meet learners' needs well by taking account of prior learning, reflecting carefully on group composition, setting and sharing high expectations in tasks and activities whilst providing appropriate support. In too many classes, in the primary and secondary sectors, all children and young people learn in a whole-class setting, carrying out the same activity at the same level of difficulty at the same time. This often results in more able children and young people in particular, not being sufficiently challenged. In the primary sector, differentiation is often achieved in other areas of the curriculum but is not consistently a feature of learning in the sciences. Staff in all sectors need to reflect further on how they plan learning across levels to meet the needs of all learners. For example, planning appropriate learning in challenging contexts for some young people at S2 who are able and ready to experience learning at the fourth level. Many staff in special schools should reflect on how they might have higher expectations for learners by planning for them to experience and engage in more challenging learning. For example, offering opportunities to experience learning at a higher level than the level at which the learner is achieving generally.



Good Practice Example 17

One secondary school built learning challenges into their new S1-S3 learning programme. One such challenge involved young people working in groups to a design brief within a fixed timescale. They had access to a range of materials and equipment and were challenged to design a 'celebrity tour bus' with multiple coaches with specific functions such as lights switching on and off independently of one another. This required young people having to work together effectively as a team to apply their learning in an unfamiliar context. The young people reported that they found this task to be really challenging and great fun. They reported a sense of achievement in managing the task despite thinking that it was impossible at the beginning.

Good Practice Example 18

Learners in one secondary school took up a 'Sciences Solutions' challenge. Young people worked in pairs, each of whom were given a challenging task briefing at the beginning of a four week learning block. Challenges were differentiated and open-ended to meet a range of needs. As the block progressed, young people were responsible for managing their own learning, preparing a learning log to ensure that they had gathered all of the learning required to successfully complete the challenge task. Young people felt they had opportunities to be creative, working together to design a solution. They reported high levels of motivation and interest, and felt they were able to work independently to extend the original challenge. As part of the assessment, learners were videoed explaining their challenge solution and the underpinning science. This work was presented to parents and at a transition evening.

Breadth

When planning breadth of learning, staff have found it useful to consider breadth as:

- a focus on an increasing number of experiences and outcomes;
- the use of increasingly detailed explanations and descriptions;
- access to an increasing range of texts to support literacy;
- demonstrating an increasing range of skills and concepts in numeracy;
- the use of a wide range of scientific language; and
- the use of a wide range of relationships including expression of those using formulae.

Although a variable picture, few primary schools in particular, have yet developed an overall plan to ensure sufficient breadth in advance of children experiencing learning programmes. Often, an audit reveals that there are gaps in learning and teachers subsequently develop approaches to address these gaps. Sometimes, plans to address these include 'themed days' or 'themed weeks' which do not always provide a coherent or progressive experience for children and young people.

In most secondary schools, staff are carefully planning learning programmes linked to the experiences and outcomes to ensure coverage of key areas of study. In some schools, early specialisation through subject choice is impacting negatively on the breadth and depth of learning. In a number of cases curriculum structure is not in keeping with Curriculum for Excellence and can lead to early narrowing of learning for young people. For example, some structures with whole cohort specialisation at the end of S2 enforce young people to study their chosen science(s) to qualification level in a two year course. Other schools, offering subject choices at the end of S1 with whole cohort early presentation for national qualifications at the end of S3, are also not in line with national expectations.

In the primary sector and at the early stages of secondary school, there is generally less emphasis in the key area of Topical Science than on the other four organisers, namely Biological Systems, Electricity, Forces and Waves, Materials, and Planet Earth. In these cases, children and young people do not have enough opportunity to discuss and debate a range of ethical issues. Most schools across all sectors are providing ample opportunity to develop well learners' knowledge of sustainable development. Staff in special schools often report that limited access to specialist equipment can present challenges for them as they endeavour to ensure learners' entitlement to a broad general education. They do however often cover aspects of the key areas Planet Earth and Biological Systems well.

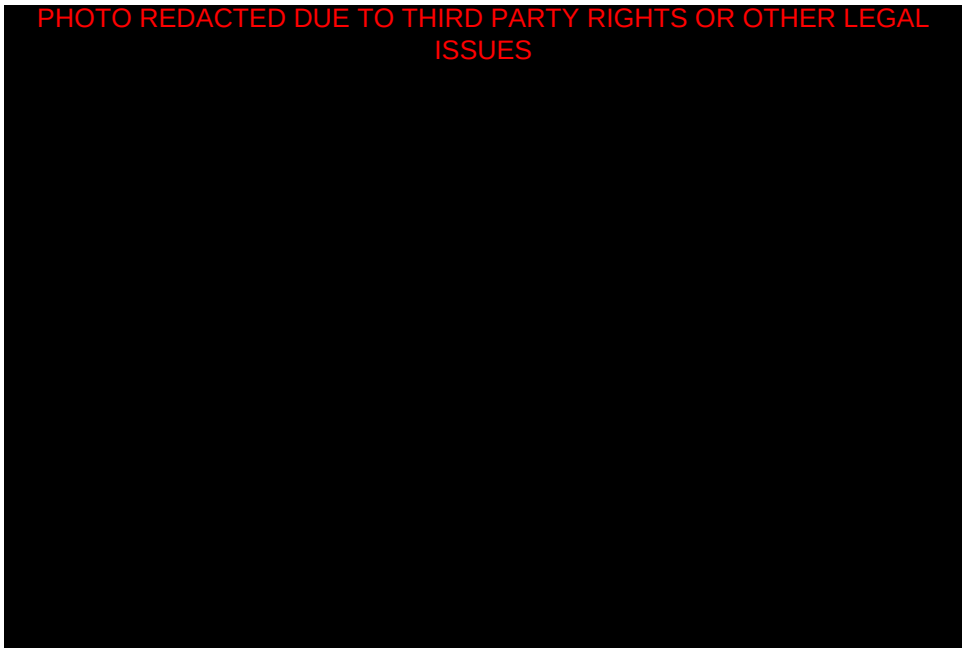
Good Practice Example 19 - **New to this updated version of the report**

One special school has utilised its very strong cluster partnership with a local secondary school to plan and develop a whole school sciences learning programme. The programme is planned taking into account each learner's level of skill, knowledge and understanding. Careful planning ensures that each learner has access to a broad general education, including those with more complex needs. One creative project was planned to develop learners' STEM skills. This was planned in partnership with the technologies department from a local secondary school and involved designing and building bird boxes. It was delivered through a challenging real-life context, developing learners' creativity, team working and problem solving skills. This partnership approach provided shared activities and experiences for learners and gave them access to the specialist equipment required to construct the bird boxes to scale and use engraving tools to make box house plaques. Learners developed their confidence and presentation skills through showcasing their skills, knowledge and understanding at the National Science and Engineering Week and parent workshops. Learners' self-esteem will be enhanced through the display of the boxes in the school grounds as part of the school Grounds for Learning programme.

Progression

Activities which are planned, or those which a learner chooses, should build on their prior learning and provide progression through breadth, challenge and application. Where staff within schools, across sectors and in clusters are working together and using the experiences and outcomes effectively to plan programmes of learning, children and young people are progressing well. Although there is variation, staff from across all sectors are finding it challenging to plan progression of learners' knowledge and skills within and across levels. Skills progression in particular is consistently identified as an area requiring development. Further work is required within learning communities and across clusters to develop and implement a shared plan to facilitate the progressive development of knowledge, understanding and skills in the sciences.

Partnership working between pre-school centres and primary schools continues to improve. Children's breadth of learning across the experiences and outcomes and their achievement in the sciences could be captured better in transition records to allow smoother progression. Partnership working between the primary and secondary sectors in the area of the sciences has been improving in recent years. There are numerous examples of positive partnerships enhancing the sciences curriculum. These include children from P5 to P7 visiting the associated secondary school to attend science clubs, complete joint projects and experience lessons taught cooperatively by primary and secondary teachers, or secondary teachers visiting children in their own primary setting to support learning and teaching. Increasing numbers of primary schools are developing approaches to capturing achievement in the sciences in the P7 profile. Although numerous positive initiatives are being developed, staff in most secondary schools still do not have sufficiently robust information on children's prior learning, progress or achievement in the sciences to plan progression appropriately.



Good Practice Example 20 - **New to this updated version of the report**

One primary school has successfully planned high-quality progressive programmes of learning in the sciences through collaboration and participation in effective cluster learning rounds. Teachers from Primary 5, 6 and 7 observed science lessons in S1, S2 and S3 with a secondary colleague undertaking reciprocal visits to observe science lessons in the primary school. The focus for the partnership work was to explore how breadth, depth and challenge in learning were being addressed. Teachers were also keen to ensure that;

- children and young people were being given appropriate opportunity to apply their skills in new contexts;
- planning was taking into account learners' prior learning to avoid duplication of content; and
- planning was ensuring progression through building on prior learning.

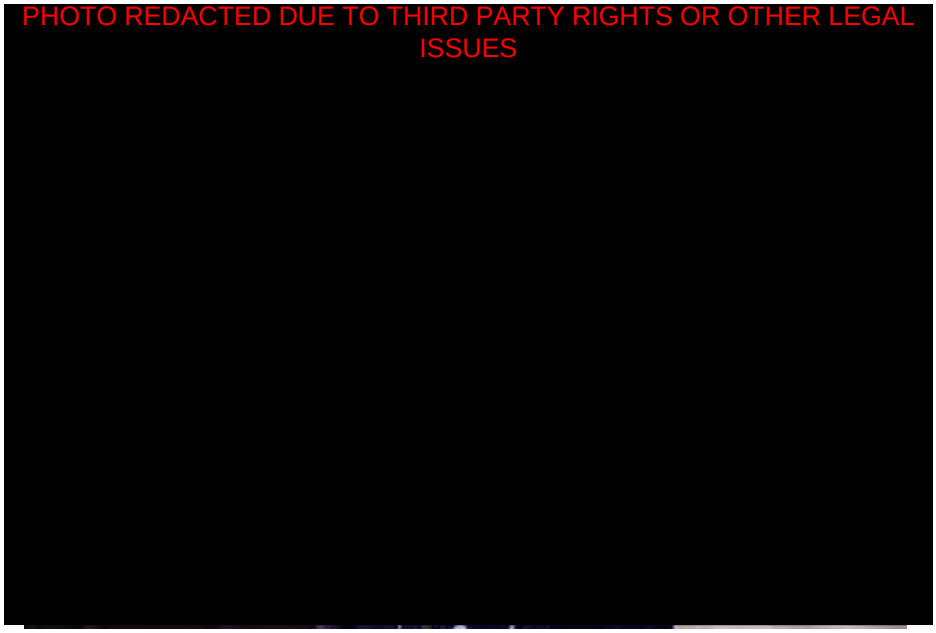
Staff used the evidence from the learning rounds in conjunction with the relevant science documentation - Concept Development in the Sciences, Assessing Progress and Achievement in the Sciences and Sciences Principles and Practices – to create well-planned learning programmes detailing clear lines of progression across all five organisers and the other significant aspects of learning. Teachers planning together in this way were able to gather very good evidence of how well children are progressing through the levels. This work has impacted very positively on staff motivation and confidence, pupil engagement, enjoyment and achievement.

Good Practice Example 21 - **New to this updated version of the report**

Successful partnership working between primary schools and their associated secondary school has raised the profile of the sciences and improved continuity in learning for learners in moving from P7 into S1. Children at P7 have become more engaged with the sciences as a result of the implementation of stimulating sciences learning programmes. This has been achieved through effective collaborative planning with staff across the cluster. Children have developed further enthusiasm for the sciences through attending a secondary school science club and participating in a creative transition project. Set within the context of the Commonwealth Games children researched DNA, applied their learning in making DNA necklaces and explored the genetic profile of athletes through electrophoresis. This work has been moderated by staff from primary and secondary working collaboratively. This together with assessment evidence in the sciences and information in the P7 profiles, has been used to determine each child's achievement in the sciences and is used to form a valuable personalised transition document. This comprehensive document has been used by secondary staff to plan learning for those entering S1 which ensures young people progress across all significant aspects of learning in the sciences.

In primary schools, learning in the sciences is too often predominantly or exclusively delivered through an interdisciplinary approach which is not planned sufficiently well to develop knowledge and skills in a progressive way. Often in these instances, there is insufficient science being experienced, resulting in gaps in learning. This is not providing a sound basis for progression to more advanced study. A few children in primary school, whose experience of the sciences was exclusively through an interdisciplinary approach could not identify having studied any science.

In secondary schools, individuals will progress towards the fourth curriculum level experiences and outcomes at different rates. A school's curriculum plan needs to be designed to enable individual learners to make this transition at the appropriate time. Many secondary schools are planning their curricula so that young people work across the third and fourth levels within curriculum areas throughout S2 and S3, and progress to the fourth level as and when they are ready, with a degree of choice and specialisation in S3.



Good Practice Example 22

Children in one primary school demonstrated high levels of motivation and interest in the sciences. A strategic plan outlining progression in developing children's skills and knowledge and understanding underpinned the learning. The headteacher used this framework to encourage staff to develop exciting, creative contexts familiar to children's experiences. Partnership opportunities were maximised. For example, a local bee keeper worked closely with the school. One group of children with barriers to learning demonstrated an in-depth knowledge of bees, their behaviour and their impact on the environment and the economy.

Depth

In most classes, children and young people are experiencing opportunities to deepen their learning. Where staff have planned learning well in interesting and motivating contexts, children have sometimes developed knowledge beyond their age and stage. Learners often have opportunities for example, to research topics and to make artefacts such as model cells or atoms to help them deepen their knowledge. On occasion, children and young people deepen their learning through taking on responsibility for leading learning. For example, towards the end of a unit of work, young people can assume responsibility for one aspect of learning and prepare presentations and quizzes for the rest of the class to reinforce and revise learning.

Too many staff from across all sectors are still not aware of the *Sciences: Concept development in the sciences (2009)* paper and learning consequently lacks depth in a few key areas.

Many practitioners have engaged in dialogue with colleagues within their own school and with others from schools across their education authority through moderation meetings. These meetings thus far have mainly had a focus on literacy and numeracy. Such practice is still not yet a common feature in the sciences. At times, staff across sectors do not understand the depth of treatment required at a particular level in the sciences and are unaware of the national standard for a given level. This results in a lack of depth of children and young people's understanding.

Good Practice Example 23

The 'Reebop Project' was used by learners in P7 to develop an understanding of genetics, variation and inherited characteristics. Working collaboratively, children applied new learning in a relevant context. The teacher adapted the resource to meet the needs of learners through planning an increased degree of challenge in the activity. Children were required to use literacy, numeracy and problem solving skills leading to deeper learning. The hands-on practical nature of the activity, with learners building a model of their Reebop, and the level of discussion as children worked together to respond to the challenge, resulted in them being able to access a conceptually difficult area of the sciences.

Personalisation and choice

Personalisation and choice are playing an important part in maintaining learners' motivation, providing challenge and preparing them for progression. Across all sectors, there are many examples of staff motivating learners and meeting individuals' needs through personalising learning. In the pre-school sector, planning often centres around children's interests and seasonal and cultural events. In the primary sector, planning is increasingly involving learners selecting:

- which topics they would like to study;
- what they would like to find out;
- what sources and types of evidence they will use;
- how they would like to conduct research;
- how they would present their findings to others; and
- how they would evidence their learning.

Personal learning planning and target setting approaches are increasingly providing more scope for planning for personalisation and choice. In the secondary sector, there is a need for some teachers to develop an improved understanding of the meaning of personalisation and choice, in relation to specialisation. For example, teachers often consider personalisation as being specialisation only, as young people select one, two or sometimes three science subject choices for further study at the fourth curriculum level. Specialisation through choice can be a feature of personalisation of learning for a young person progressing towards achieving a broad general education. However, there is rarely evidence of the learning within a young person's science choice(s) being personalised for them as an individual learner. Staff across all sectors need to continue to develop approaches to ensure personalisation and choice taking greater account of individual progress, preferred ways of learning and learners' aspirations.

There are emerging issues around the timing of specialisation through subject choice across S1 to S3 stages in some secondary schools. There are a range of curriculum models emerging which range from young people choosing to specialise in one science subject at the end of S1 to continuing study in all three until the end of S3. It is not evident in the various curriculum plans involving such early specialisation that young people's entitlement to a broad general education will be met. For example, it is not evident in cases involving such choices that young people had achieved sufficient depth of learning and the ability to apply this learning at the third level confidently in different contexts. Secondary schools continue to review and refine their arrangements. Where specialisation prior to the end of S3 is in place, sometimes electives or interdisciplinary projects are planned to support continuing experience and progression in the subject(s) not chosen. Whatever curriculum plans are developed by a school, they must deliver on the entitlement to the broad general education.

Good Practice Example 24 - **New to this updated version of the report**

One secondary school has successfully used QR Coding to make homework more accessible for young people and enhance opportunities for deeper learning. Each homework exercise which is issued in written format has an allocated QR Code. Young people can easily use QR readers on their mobile phones or other mobile devices to access homework prompts if they experience difficulty or to access resources which can allow them to study each topic in greater depth. Young people without access to computers or laptops with internet connection have found the use of mobile devices a valuable way of engaging in learning outside the classroom.

Coherence

Children and young people can often talk well and with enthusiasm about their learning and display an understanding of how aspects of their learning in the sciences are connected to other curriculum areas. Equally, children can often relate their learning across the curriculum to their learning in the sciences.
There are a few examples of teachers having worked together to identify key concepts which they felt should be developed to provide a sound basis for more advanced study in the senior phase. They subsequently planned this concept development into learning programmes and pathways in an effective way. Too often, curriculum managers and teachers, sometimes as a result of trying to manage limited resources in the best way possible, arranged topic sequences that required young people to apply knowledge that they would not be gaining until a later stage in their learning. In such cases, there is a need to ensure that learning sequences are well-planned to develop concepts in a coherent way. The *Sciences: Concept development in the sciences (2009)* paper could be used better as the basis for such planning.

Relevance

Relevance is a strong feature of learning in the sciences in all sectors. Staff often plan learning to ensure that children and young people are able to make a connection between their learning in the sciences and their everyday lives. Increasingly, staff are using more real-life and interesting contexts for learning. In pre-school centres, children often learn through discovery in the sand, water and construction areas of their learning environment. Outdoor learning using the local and wider environment to support the learning is often a key strength across all sectors, providing relevant contexts for learning. For example, children can learn where some of their food comes from, study biodiversity and develop an understanding of sustainability through growing and cultivating their own plants in their eco gardens. They can also explore, sample and investigate the habitats of mini-beasts, and learn how to categorise and care for organisms in their eco gardens and greenhouses that sometimes have been created from recycled bottles. Learning in the classroom is often related to real-life situations. There is room to build on this work, particularly in secondary schools, and to develop learning in a wider range of stimulating and real-life contexts. Too often learning is introduced in fairly traditional topics such as ‘cells’ or ‘materials’ where the same learning could be better received in a context which is more relevant or stimulating for young people.

Good Practice Example 25

One primary school engaged children very well with their local environment through partnership with the Galloway Fisheries Trust in the 'Clyde in the Classroom' project. Children reared trout fry in a classroom hatchery before releasing them into the local river. Children's knowledge of lifecycles and the basic needs of living things were developed as they cared for the trout fry. Working on the project provided a context for developing numeracy and literacy skills, for example through creative writing tasks and activities such as estimating and measuring the length of the developing fry. It also helped the children to understand the geography of their local river network and provided a relevant context for learning about the effect of our actions on an ecosystem.

Good Practice Example 26

Traffic police worked with young people in secondary schools with the aim of promoting road safety. They worked with young people within the broad general education and in the senior phase on areas of learning such as the relationship between speed, distance and time, and momentum. Young people were shown how quadratic equations are used in accident investigations and that understanding of physics is a crucial element of accident analysis. Through this work, young people were given the opportunity to use and develop their numeracy skills in a real-life context.

Good Practice Example 27

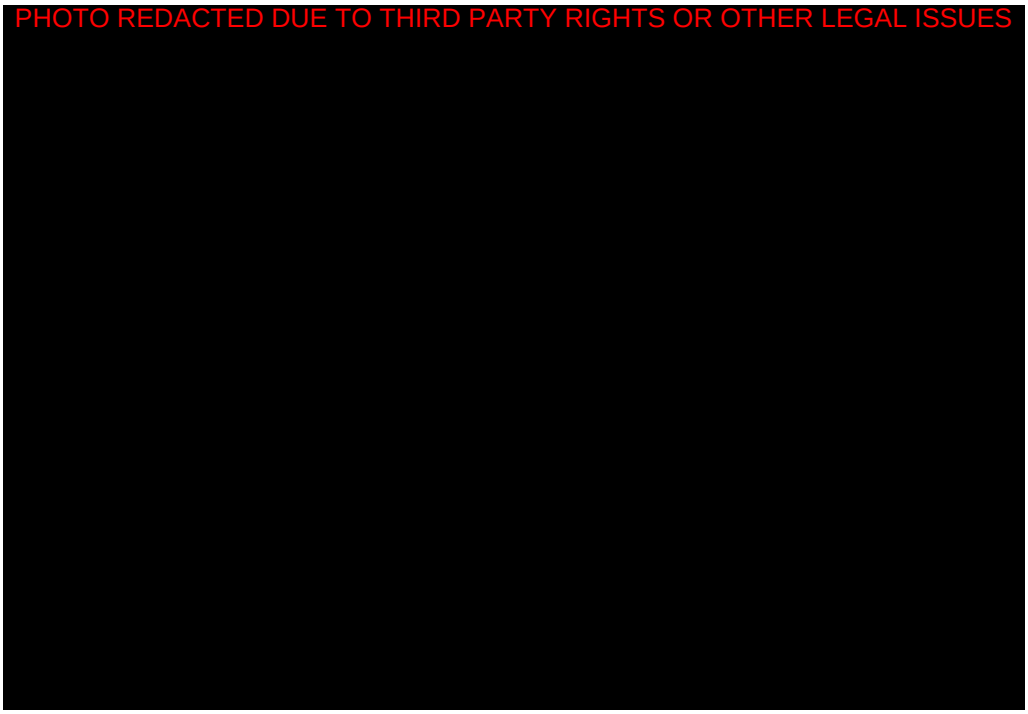
In one secondary school, an S1-S3 integrated science course offers opportunities for exciting, relevant and topical contexts for learners. The sciences staff have worked together to prepare well planned and innovative topics, for example 'Scrubs' and 'Who Wants to be a Scientist?', through which young people experience learning which integrates experiences and outcomes traditionally approached with biology, chemistry and physics topics. Where appropriate to their needs, young people have the opportunity to experience learning at fourth level within these integrated topics, to challenge and extend their understanding.

Good Practice Example 28

One school has formed a positive partnership with staff of a local country estate. Young people studying the sciences can visit the estate and experience their learning in a real-life context. They can work with the estate managers, rangers and other estate workers as they observe what they have been their learning in practice. For example, the learning for one physics class was contextualised as they observed electricity and circuits being used for electric fences and cattle management, incorporating opportunities to consider potential hazards and risk management.

Good Practice Example 29

In one secondary school, staff from a local pharmaceutical company supported young people at S5 as they completed one of their prescribed practical activities for their Higher chemistry course. The pharmaceutical staff supported young people in developing the necessary practical skills and knowledge of up-to-date equipment. Young people could understand their learning in relation to a commercially relevant environment.



Learning and teaching

How effective are learning and teaching approaches in the sciences?

'Although the content of the curriculum is important, the high aspirations of the sciences curriculum within Curriculum for Excellence will only be achieved through high-quality learning and teaching. The sciences experiences and outcomes are designed to stimulate the interest and motivation of children and young people and to support staff in planning challenging, engaging and enjoyable learning and teaching activities. They allow flexibility and choice for both teachers and learners to meet individual learning needs'.

Sciences Principles and Practice (2009)

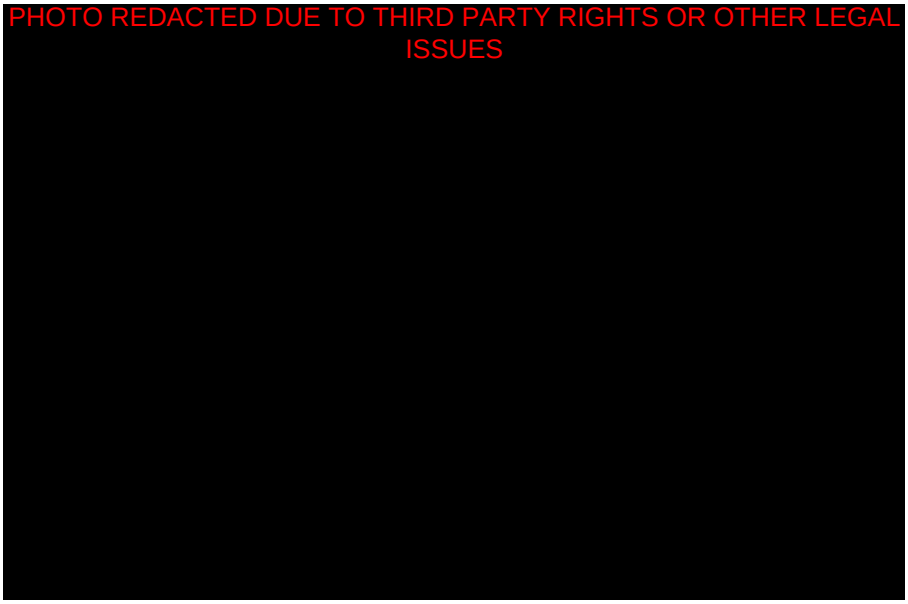
Overall, **learning and teaching** in the sciences is strong, effective and improving. There are examples of very good and outstanding teaching. For many schools, improving the consistency of the quality of learning and teaching remains a top priority. There is still work to do to share good practice both within schools and across schools effectively to help raise standards.

Secondary staff have **strong subject expertise** and are enthusiastic about their subject. Staff in all sectors are generally well-prepared for lessons, and are committed to providing high-quality learning experiences for children and young people. They are successful in creating a positive ethos for learning where learners feel comfortable to volunteer answers during class discussions and ask questions to help them develop their thinking. Children and young people continue to benefit from an encouraging learning environment which promotes **positive attitudes** to the sciences.

Teachers are increasingly planning opportunities for children and young people to become **actively involved** in their learning and achieve success. They often use questioning very well to recall and consolidate learners' knowledge but there is variability in using it effectively to develop thinking and understanding. Since we last reported in *Science: A portrait of current practice (2008)* which provided signposts for staff on developing the four capacities within the sciences and an *Improving Scottish Education: A report by HMIE on inspection and review 2005 -2008 (2009)*, we are observing less use of low level tasks such as copying notes, cutting out sections from handouts, pasting into jotters and colouring in. Children and young people are now generally experiencing a greater variety of learning and teaching approaches which is sustaining their motivation and developing their interests.

- Across all sectors, children and young people experience activities which require them to **work independently or collaboratively with others** in pairs, trios or to complete learning challenges as part of a larger group. They are increasingly experiencing opportunities to discuss and reflect on ideas and their experiences. Often, the importance of team-working skills and success criteria to exemplify what good teamworking would look like are shared with learners. Many schools are using cooperative learning techniques with children and young people to develop these skills. In other schools, there is scope to develop this approach further.

- In pre-school centres, special schools and primary schools, staff develop citizenship **skills** well through providing appropriate opportunities for children to develop respect and learn to care for living things, including using their eco gardens to explore the diversity of inhabiting creatures. Children in special schools use their eco garden to collect and classify natural materials, compare and contrast these with synthetic materials and present their findings in ways such as creating a collage. In primary and secondary schools, many teachers help children and young people to develop as responsible citizens. For example, teachers are making good use of current issues in the sciences reported in a variety of media formats such as newspapers, TV, radio, internet and scientific publications. Children and young people use these to evaluate environmental, scientific and technological issues. They sometimes carry out surveys of members of the local community to investigate issues such as waste management, recycling and carbon footprint. This has sometimes led to learners developing a Travel Plan for the community and producing helpful information on reducing carbon footprint.



- Across all stages learners' experiences in the sciences are increasingly being enhanced through opportunities for learning out-of-doors, field trips, visits to science centres, local, national and sometimes international facilities. They participate in science clubs, local and national challenges, visit interactive science exhibits and science workshops, work in school grounds and on local environmental projects, blog about their activities on science websites and communicate with schools and other partners using information and communications technology (ICT). In pre-school centres, children are developing their observation, recording and classification skills well through working with real materials, artefacts and living things in **real-life settings**. For example, children compare and contrast the types of plants growing in their eco garden across different seasons. The use of the outdoors to develop important skills is emerging as a strength across all sectors.

- At the primary stages, children are often experiencing activities to develop **scientific literacy**. For example, children research a topic such as 'endangered animals', source a range of reliable resources, select and collate appropriate information, process, summarise and present their findings.

- At the primary stages, children carry out simple investigations, make predictions, take account of the importance of carrying out a fair test, record results and draw simple conclusions. There is scope for children to be engaged further in such fruitful **investigative work** as this is not a consistent enough feature of learning in the sciences across primary schools.

- Staff in primary and secondary schools in particular are increasingly planning opportunities for learners to present the findings of their work to others. This develops confidence and skill in **scientific communication** and allows learners to personalise the learning by choosing their preferred presentation style. This often includes oral presentations using slideshows, scientific information posters, photographs, film clips or role play and other types of performances.

- In a few classes, particularly at the secondary stages, young people take part in stimulating group **discussions**, debates and decision-making exercises around topical issues. These include for example examining the issues around the use of stem cells, cloning, climate change, genetically modified foods and the use of renewable energy sources. In the best examples young people are expected to express and justify the positions they are taking. Across all sectors, the use of debates and class discussions to help children and young people develop informed, ethical views of topical issues in science is not a common enough feature of learners' experiences in the sciences. The website 'Speak up Scotland' may help practitioners develop this area.

- At S1 and S2 young people generally have plenty of opportunity to carry out practical work allowing them to develop a range of practical technique and **investigation skills** often within relevant and real-life contexts. They often cite this aspect of their learning as one of the main reasons they enjoy science. At these stages teachers plan practical investigations with appropriate emphasis on planning fair tests, collecting evidence, observing, measuring, recording, interpreting and evaluating. At times, practical work in all sectors is still too prescriptive and teacher-led thereby not allowing the development of learners' creativity and inquiry skills. In such cases learners are not given enough responsibility to plan practical work and to select equipment and resources that they will need.

- In the best examples, children and young people choose challenging topics to study in-depth in open-ended investigations and projects which develop their **higher-order thinking skills**. This is not yet a consistent feature of learning in many schools and learners need to experience more of this type of learning.

- The use of **ICT** for stimulating, supporting and reinforcing learning is improving as overall ICT provision in schools is generally improving. This includes the use of animations to help to clarify difficult concepts, allowing learners to research, analyse and present scientific data, using a video-conference facility to enhance a real-life context or learners using interactive whiteboards to explain learning to each other. However, the use of ICT to carry out, collect and present findings from experimental work is still too limited.

Good Practice Example 30

In a pre-school nature kindergarten, the children spend almost all of their time outdoors. This provides them with a rich natural environment which is used very effectively to promote early science skills and develop children's interests in living things. Effective shared planning for learning allows children the space and time to explore and discover their natural environment. This is supported by well-timed and skilful interactions with staff. Children are developing their powers of observation and investigation very well. They are well aware of change and its effects on them, for example, their own growth, changes in weather, trees, flowers and plants. Children enjoy observing living things, for example, they know where to find the 'toad' outdoors in the garden. They are learning about planting and growing and know that you need sunshine and rain to make some things grow for example, carrots, peas, onions, strawberries, tomatoes, planting trees. Through their daily walks into the wild wood, children explore their natural environment and fulfil their inquiry, creativity and problem-solving skills.

Good Practice Example 31

In a special primary school, children with complex needs are motivated by high-quality learning experiences which ensure that they are actively involved in their own learning. Almost all of the time they participate enthusiastically in lessons and show confidence and enjoyment in learning. Effective community learning partnerships enhance learning. Children regularly visit local community facilities. They also carry out activities in the school grounds to enhance the environment. In the sciences, children know about aspects of nature, for example, through exploring outdoors. They also use their senses when working with ingredients e.g. using cornflour mixed with red colouring, making playdough and watching ingredients change during cooking processes. Children are actively involved in making and watching activities around their bird feeders. Effective use is also made of photographs to track and assess progress both in school and at home.

Good Practice Example 32 - **New to this updated version of the report**

Discovering an invasive species of worm within their school grounds and sharing the news with the scientific community was just one of many exciting moments for children turned citizen scientists at one primary school. Through their citizen science activities, children developed a range of scientific skills including measuring accurately, recording, classifying and observing. Information and communications technology (ICT) and literacy skills were also developed in the process of uploading data to the OPAL website and recording experiences and learning in their John Muir Award journal. Partnerships with local conservation groups and a university enabled detailed study of the biodiversity and impact of climate change on the local river. Children reported an increased enthusiasm for science and a new-found pride in their local community and its natural assets. Children who required additional support with their learning were fully included in all activities and had grown in confidence as a result. Find out more about Citizen Science surveys.

Good Practice Example 33

Children and young people in three education authorities worked collaboratively to achieve deep learning in the sciences, using learning materials developed by initial teacher educators and funded by an external trust. Learners reported high levels of motivation and enjoyment, engaging with practical investigative work to solve a challenge, over about six lessons. Collaboration and sharing findings took place using Glow Wikis and Glow Meets. Children and young people responded very positively to this approach and developed their ICT skills. Staff noted the extent to which learners were writing independently on the Glow Wikis to discuss findings, and express conclusions drawn from the available evidence. Evaluation indicated children and young people benefited from participation in the learning. The education authorities involved are sharing this good practice and extending the work further.

Good Practice Example 34

Young people at S2 discussed learning outcomes and agreed success criteria with each other and their teacher for a piece of practical work prior to them carrying out their investigative work in groups. Using mini video cameras and their ICT skills each group filmed another group carrying out their investigation. On completion, they watched the films, analysed their own and each others' practical techniques and evaluated achievement against the learning outcomes and success criteria. Next steps in learning were identified for individual learners.

Staff are building on the principles of '**Assessment is for Learning**' and this has resulted in learners benefiting from an overall improvement in approaches to learning and teaching. For example, learning outcomes are often shared with children and young people in order to focus their learning and in the best examples are used well to evaluate achievement. The use of success criteria and agreeing these with children and young people so that they understand what learning will look like and allow them to evaluate their learning is less well developed. There is increasing use of self and peer-assessment so that children and young people can understand themselves better as learners and learn from each other through commenting constructively on each others' work. There is still scope for teachers to improve the quality of feedback they give to children and young people on their work in the sciences. Dialogue with learners to support them in their learning is often not sufficiently well developed. In particular, children and young people often cannot sufficiently recognise their strengths, areas for development and next steps to improving their learning. Children and young people are not yet sufficiently involved in setting learning targets and personal learning planning is not yet a strong feature in the sciences. It is worthy of note here that in a number of cases these are key features of learning in other areas of the curriculum in the primary setting but are not true always for the sciences.

There are some strong examples of **homework** in the sciences being used well to promote thinking as well as provide opportunities to consolidate and apply learning. This is not a consistent feature of learning across primary schools and the early stages at secondary.

Good practice Example 35

Children in one primary school benefit from the active role their parents take in contributing to their learning. Children and their parents across all stages in the school complete highly motivating science challenges at home. The challenges are planned, progressive and involve children applying their learning in a new context. They relate to real-life contexts and link coherently to the very well planned approach to developing children's skills, knowledge and understanding in the sciences. Challenges are open-ended with clearly defined success criteria for assessment. Challenges are assessed using a range of approaches. For example, a child made a model and shared what he learned with his peers. Another child used video clips in a presentation to demonstrate her learning. Parents felt supporting their children with the science challenges kept them well-informed about their child's progress in science as they move from nursery to primary 7.

Young people from S3 to S6 value the variety of approaches that their teachers employ to support their learning, especially in helping them prepare for **national examinations**. Approaches include provision of extra study classes at lunchtimes or after school, providing resources for independent study through the school website, by supplying CDs containing resources and accessing support for learning beyond the classroom through Glow.

How are skills being developed in the sciences?

In a few schools, staff are clear about what skills they are trying to develop in children and young people, what progress in these skills will look like and how they will assess learners' progress. They engage children and young people in making them aware of the skills that they are developing, how they will be taken forward and how they will be assessed. In the best examples, staff plan opportunities to revisit learning at different times, use different contexts and provide increasing levels of challenge to ensure progression. Currently, these examples of good practice demonstrating key features of planning for skills development are not consistent across all sectors. A few staff have used the Revised Bloom's Taxonomy (2010) of skills in considering, discussing and constructing a plan for skills development. Many staff across all sectors need to focus further on supporting the progressive development of skills through planning increasing complexity of scientific contexts and concepts, and revisiting and reinforcing the skills, making reference to the guidance within the *Sciences Principles and Practice (2009)* paper and *Building the Curriculum 4 (2009)*.

A few education authorities have created 3-15 'progression frameworks' to support staff in the development of learners' knowledge, understanding and skills in the sciences. Although described as a 'work in progress', staff in these education authorities have found the frameworks a useful reference point for their planning. Despite some positive initiatives in this area, skills development overall, particularly the development of higher-order thinking skills, needs to be better planned and assessed.

Good Practice Example 36

Young people in a senior phase sciences class worked in pairs to research one aspect of a topic and write and record a podcast for classmates. They each put all of the podcasts on their MP3 players or mobile phones to use for learning and later revision. Young people reported feeling a sense of responsibility to ensure their work was of high quality, clearly explained and submitted on time to benefit others. They approached the task by first discussing and considering the Revised Bloom's Taxonomy (2010). This provided them with a framework to plan the task through identification of the required learning and thinking skills. For example: Remember - find the information; Understand - convey the information in their own words; Apply - apply the information they have gathered to the specific context with which they were working; Evaluation - evaluate the sources for reliability and quality; Analysis - select the most appropriate information for inclusion; and Create - bring the various information together in their own words, in an appropriate order, communicating clearly to help others' learning. Staff noted increased pupil engagement, not only when preparing, creating and generating their own podcast but also when listening to others' podcasts. Learners felt they understood more about using their thinking and learning skills to learn from others' work, and that they had benefited from taking responsibility for their learning.

The young people used self and peer-assessment based on the Revised Bloom's Taxonomy throughout their learning in this subject and described feeling that they had a much better understanding of their learning and how to achieve success in the sciences. The approach was then used with other classes. This good practice was also shared with other teachers, building capacity to enable them to use it with their classes.

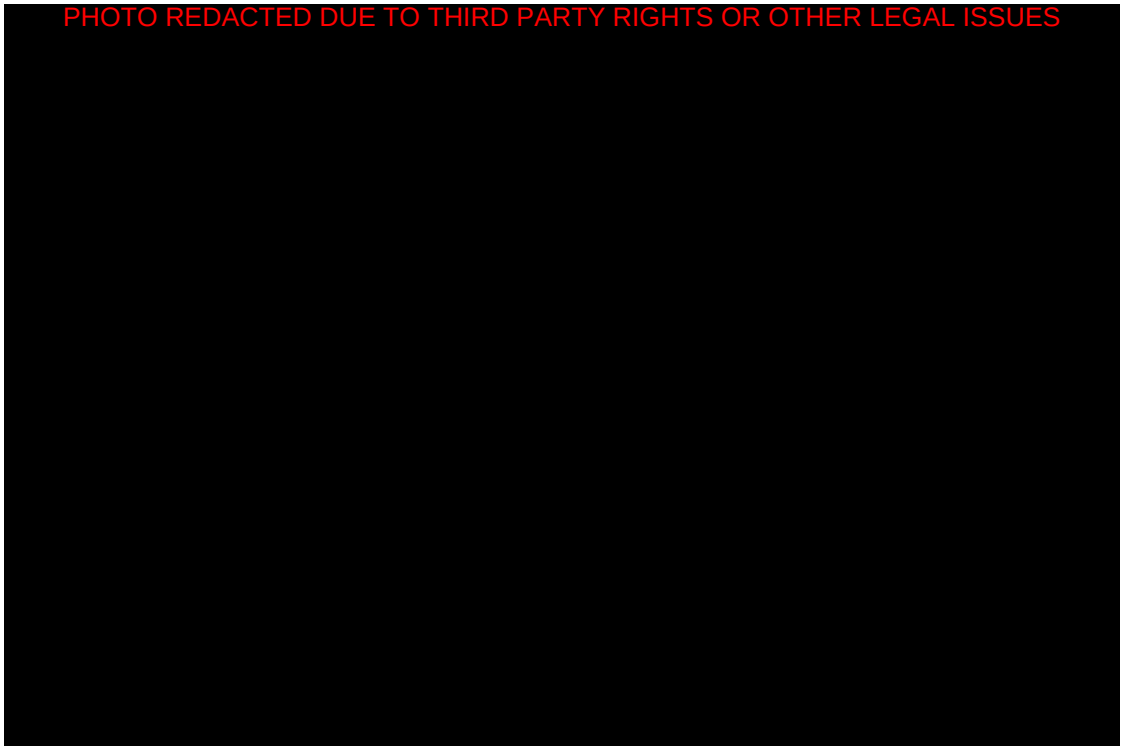
How well are staff assessing children and young people's progress in the sciences?

Many schools are aware of the need to develop a wider range of approaches for assessing learners' progress in the sciences. Staff are increasingly developing a variety of approaches to capture what children and young people can 'say, write, make and do'.

Planning does not always give sufficient consideration to how they will assess progress in breadth, challenge and application. In the best examples, staff involve children and young people in assessing their progress. They share the learning which will take place with learners and give them responsibility for gathering evidence of their learning. Evidence of learners' achievements can take many forms, including floor books, story boards, hand written reports, reports that they have produced using software packages, photographs, film clips, models, simulations, scientific posters and end of topic tests. Learners take responsibility for gathering their latest and best examples of achievement and organise them in a range of ways including folios, learning logs, learning stories and e-portfolios. Staff and learners together assess progress at key milestones and set learning targets for future progress.

Although progress is being made towards developing a range of approaches to assessment, there is much scope for improvement in this area across all sectors. The focus in most primary schools has been on developing programmes and assessment approaches for literacy, numeracy and health and wellbeing. At this stage, most staff are not yet assessing, recording or tracking children's progress in the sciences in a systematic way. Primary and secondary schools are not yet at the stage where they can provide sufficient evidence of learners' achievement in the sciences in the broad general education phase. In secondary schools, assessment is still largely of a summative nature and does not reflect progress across the range of experiences and outcomes. In primary and secondary sectors, there is some way to go to ensure that assessment is truly part of learning and teaching and informs learning and next steps.

Across all sectors, many staff are not yet confident in judging when a learner is achieving a curriculum level in the sciences. Many are not yet sufficiently confident in planning and assessing using the significant aspects of learning in the sciences and have not yet developed an understanding of standards across curriculum levels. A professional learning resource Assessing Progress and Achievement in the Sciences has been developed to support practitioners with assessment. In most associated school clusters and learning communities, moderation activities thus far have mainly been focused on literacy and numeracy. Staff need more opportunities to participate in moderation activities in the sciences both within and outwith their school to help them understand, apply and share standards. For the reasons just outlined, staff are therefore finding it difficult to report on progress and achievement.



Achievement

What is learning in the sciences enabling children and young people to do through the broad general education?

At this stage in the development of the broad general education, most schools do not yet have comprehensive approaches to assessing and tracking learners' progress. As a result they do not yet have a robust picture of learners' achievement in the sciences. Primary schools continue to develop the P7 profile. In the best practice, children's achievement in the sciences is captured in this P7 profile. Secondary schools continue to develop the S3 profile. A number of sciences staff are still unclear as to how they can contribute to supporting young people in the completion of the S3 profile. As yet, most schools do not have a strategic plan for developing skills in particular in the sciences in a progressive way. In addition in too many cases, as described earlier, planning in primary schools and special schools in particular is not providing sufficient breadth in learning. Consequently, children and young people in primary schools and special schools in particular, are not making sufficient progress towards achieving a broad general education.

Many children and young people display features of being successful learners, confident individuals, responsible citizens and effective contributors.

- Across all sectors most learners are **motivated and enthusiastic** about their learning in the sciences. Through the variety of learning and teaching approaches described earlier, learners are engaged in their learning and, overall, maintain an interest in tasks and activities.

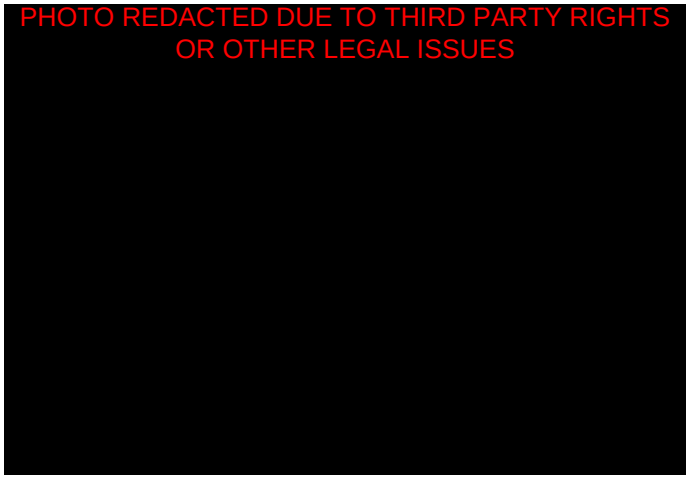
- Across all sectors, learning in the sciences is making an important contribution to developing learners' **citizenship skills**. Many have developed the scientific values of respect for living things and the environment. A strong feature of achievement is learners' increased awareness of environmental and sustainability issues. They generally have knowledge of real-life uses of science and scientific values and attitudes.

- Children in the pre-school sector are developing their **inquiry and investigative** skills well. They regularly explore, observe, record and talk about their findings. Learning is helping to stimulate, nurture and sustain children's curiosity, wondering and questioning in a variety of contexts. They often develop the concept of the passage of time, can discuss similarities and differences, compare and contrast, predict, categorise and express opinions confidently.

- Learners in pre-school centres and special schools learn how to keep themselves safe and how to look after living things.

- Where learning and teaching is focused on providing children and young people with well-planned research tasks they are becoming skilled at finding and evaluating information from a variety of sources. They are gaining a **respect for evidence** and are increasingly making informed choices and decisions on issues relating to the impact of science in society.

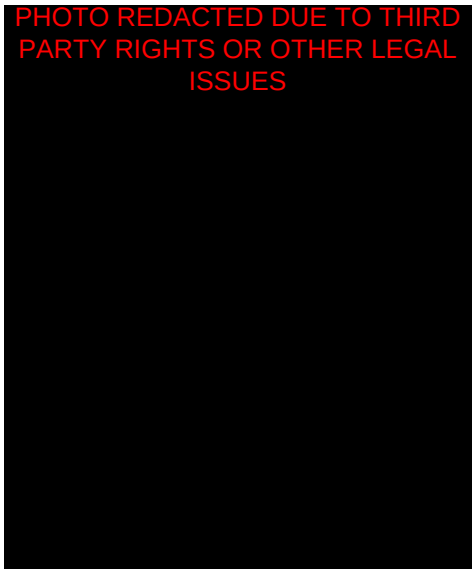
- Across all sectors, staff engage children and young people well in a range of activities to develop their capacity to be **effective contributors**. In pre-school centres and primary schools, staff develop children's talking and listening skills well in science contexts. For example, they encourage children at the early stages to discuss the conditions that will help a plant to grow. In primary and secondary schools, teachers are increasingly developing class and group discussions which encourage children and young people to think about scientific concepts, develop their talking and listening skills, think about scientific concepts and acquire the language of science. In a few cases, children and young people for whom English is an additional language are developing their scientific language through helpful customised science dictionaries and dual-labelled resources. Children and young people are now more commonly developing their skills of scientific communication through being encouraged to share the results of their investigations and research projects with a variety of audiences including peers in class or parents at sharing assemblies.



- In the best examples in **Gaelic medium** pre-school and primary provisions there is a strong commitment to teaching all subjects through the medium of Gaelic. In such cases there has been much progress in developing children's enjoyment and understanding of the sciences, as well as their use of specialist vocabulary. As young people progress to secondary, there is potential to significantly increase opportunities to extend learning in the sciences through the medium of Gaelic. In the most effective practice, staff work well together to achieve coherence and progression within a broad general education. Beyond the broad general education there is still little learning about the sciences through the medium of Gaelic.

- Where children at primary stages experience sufficient **practical activities** they generally work well together. They understand the importance of a fair test, can make a prediction, have appropriate skills in observing, measuring accurately, recording and drawing conclusions based on their results. Children are often developing skills in the accurate use of scientific language. Many need to develop further their knowledge of the units of measurement. Children can present their results in lists, tables and bar graphs, but are often less able to present their results in a line graph where appropriate.

- Young people at secondary school are developing **practical investigation and inquiry skills** within a range of relevant and real-life contexts. They can generally work collaboratively to plan fair tests, make a valid hypothesis, collect appropriate evidence, observe, measure accurately, estimate, record results in an appropriate format, interpret and evaluate findings and present them in a way of their choosing. They are often able to link two variables to determine relationships. A strong feature of practical work is young people's ability to manipulate and name scientific equipment confidently, apply safety measures and take necessary actions to control risk and hazards. Many are not yet skilled at identifying the limitations of practical technique and scientific equipment and suggesting improvements to experimental work or investigation.



How well are young people achieving in the senior phase?

In several schools visited, young people had opportunities to develop their knowledge and understanding of broader sciences issues through a range of experiences. These ranged from involvement in the Scottish Space School which for some learners incorporated a trip to NASA's Johnson Space Centre, Houston; a trip to the European Organisation for Nuclear Research known as CERN, work experience and participation in science clubs. This type of opportunity for young people in the senior phase is not consistently available across secondary schools. As noted previously, staff are not yet taking sufficient account of learning across all four aspects of the curriculum in planning learning programmes. Secondary schools are not yet fully capturing the range of young people's broader achievements in the senior phase.

Sciences are generally popular courses of study as young people progress towards national qualifications. Young people generally perform well in national examinations in the sciences. However, there is scope for improvement and a number of departments have 'raising attainment' as a priority in their departmental improvement plan. In special schools, a few young people are undertaking and achieving awards at Access, Intermediate and Higher levels. There is scope to increase expectations and raise attainment for some young people, particularly those with social, emotional and behavioural needs, and for those who are looked after.

The information in the rest of this section of the report is supplemented by information in Appendix 4.

The following information provides a brief overview of the uptake of the sciences.

Overall, biology, chemistry and physics entries for national qualifications by S4 have featured consistently in the ten most popular subjects studied by this stage over the past decade. Biology is the most popular of the three sciences by S4. Over the last decade, for Standard Grade and Intermediate 2, chemistry has almost as many entries by S4 as biology. However, only approximately one-fifth of young people taking only one of the three sciences at these levels chose chemistry.

Entries in Standard Grade science by S4 have fallen sharply over the past decade. A key factor in this trend could be that several schools have changed to offering biology, chemistry or physics at Access 3 or Intermediate 1 instead of Standard Grade science.

Over the past ten years biology, chemistry and physics have featured consistently in the eight most popular Access 3 courses studied by S4 at this level.

Over the past decade, biology, chemistry and physics have featured consistently in the six most popular Intermediate 1 courses studied at this level by S4 and are showing an overall improving trend.

The uptake figures of each of the main three sciences at Intermediate 2 level by S4 have been increasing. The main three sciences have featured consistently in the ten most popular Intermediate 2 subjects studied at this level since 2003.

There has been an overall increase in the proportion of young people taking two or three discrete science subjects by S4 over the past decade.

In the last decade, physics courses by S4 have been taken consistently by a higher proportion of boys. Although the proportion of boys studying biology courses by S4 over the last decade has been increasing, there has been a notably higher proportion of girls taking these courses. There is no notable gender difference with chemistry and science.

The sciences continue to feature in the most popular six subjects studies at Higher level.

A consistently higher proportion of boys have taken Higher physics over the past decade. Although the gender balance in Higher biology and Higher human biology is improving, a notably higher proportion of girls have consistently taken these subjects over the last decade. Chemistry shows no such gender difference.

The three main science subjects have featured in the five most popular Advanced Highers taken over the past decade.

The Scottish Baccalaureate in Science was introduced in 2009 and comprises two science courses (or one science and one technology course) plus mathematics or applied mathematics, together with an interdisciplinary project. Two courses have to be taken at Advanced Higher level and one at Higher level. The award is aimed at the highest achieving young people at the upper stages of secondary school. There has been a relatively low uptake for this award over the four sessions that it has been running, with many schools not offering it. There was a slight decrease in the numbers undertaking this is 2013. Although numbers are small the quantity of young people undertaking the interdisciplinary project Scottish Baccalaureate only has been increasing. Despite this, it continues to be the most popular choice of all of the baccalaureates with 82% of the Scottish Baccalaureates undertaken being in science.

The following information provides a brief overview of attainment in the sciences.

- Over the last decade attainment in the three main sciences at Standard Grade by S4 has been strong.

- Attainment by S4 in the three main sciences at Intermediate 1 level is improving.

- Attainment by S4 at Intermediate 2 is generally in line with that of other subjects. Attainment at Intermediate 2 has fluctuated over recent years.

- Compared to many other subjects, higher proportions of young people who achieve well in national examinations in the three main science subjects by S4 progress to studying the subject at Higher level in S5.

- At S5/6 Attainment in chemistry and physics at Higher level has been strong and has overall been improving over the last decade. Attainment in biology and human biology is not as strong but has generally been improving over the last decade.

- Higher proportions of young people achieving well at science subjects at Higher in S5 progress to Advanced Higher in S6 compared to almost all other subjects.

- Attainment in the three main sciences at Advanced Higher level is generally in line with other that of other subjects. Attainment at Advanced Higher physics is stronger than that in the other sciences.

Leadership and self-evaluation

There are a variety of opportunities for staff to develop leadership skills in schools. Some staff lead improvement groups within school, at authority level or at national level. Others take on responsibilities such as becoming eco coordinators, primary/secondary liaison link, running a science club, or taking on responsibility for developing a unit of work.

Often, learning programmes in the sciences in primary schools are well developed when one or more teachers have an enthusiasm and passion for the sciences and willingly take on responsibility for developing learning programmes. Often, but not exclusively, these teachers have a background in science or have a science qualification before entering the teaching profession. One other factor in determining the quality of sciences programmes in primary schools is whether the education authority has designated the sciences as a priority on its improvement plan. Where this has been the case, schools had science development as a priority on their improvement plans and this often resulted in positive outcomes for children.

Good Practice Example 37 - **New to this updated version of the report**

The ambition to secure positive destinations for all young people and stimulate economic regeneration resulted in one education authority developing a strategic action plan for the sciences, technologies, engineering and maths (STEM) education. A successful partnership with the local further education college was pivotal. Over £1,000,000 was secured from business sponsorship and enterprise programmes in schools which helped purchase key equipment to support learning and teaching in STEM. A further partnership with a local engineering and housing development provided further context for learning. The authority is rolling out the Primary Engineer programme to all primary schools and is making effective use of the STEM ambassador programme to build the capacity of schools. Further funding has been secured from local businesses to employ a pan-authority STEM Coordinator to take forward a 3 year early childhood to S1 STEM programme.

In schools with a strong ethos of collegiate working staff often felt consulted and fully involved in decision-making. This involvement has resulted in greater ownership of developments. In such cases principal teachers and faculty heads felt that their views had been listened to and they were clear about curriculum rationale and plans.

Almost all schools and departments visited for the purpose of this report, completed pro-formas indicating that they knew themselves well and that they could identify their strengths and areas for development. Many schools have comprehensive systems in place to manage their quality assurance programme. They use a variety of approaches to monitoring and evaluating the quality of their work including classroom visits, sampling learners' work, cross-marking, and seeking stakeholders' views. Some audit their work in the sciences using national documents, for example *3-18 Sciences Impact report 2012, How Good is our School? Part 3 (2007), an updated self-evaluation guide for quality indicators 5.1 and 5.9* and the latest *Inspection Advice Note* outlining the updated expectations of Curriculum for Excellence.

For many schools and science departments, improving the consistency of high-quality learning and teaching remains a top priority. Overall, there is still work to do to share good practice effectively to help to raise standards. Where the sciences have been a priority in the school improvement plan, we often observe children who were engaged and enthused by stimulating learning programmes in the sciences. Too many improvement plans in pre-school centres, primary schools and special schools do not as yet contain any priorities for developing the sciences.

Good Practice Example 38

One pre-school centre identified science through their self-evaluation as a curriculum area they needed to develop. The staff wanted to take a fresh approach that would maximise what they knew interested children and try to make meaningful learning links between the centre and home. Staff invited parents to plan with them and develop a shared understanding about what science means. They used children's interests in everyday things, such as, cooking, puddles and electricity, as starting points to develop a set of science boxes for children to use with parents at home. This link proved popular with children and parents alike. Parents commented positively on this 'quality time' being spent with their child.

Secondary science departments often have well developed and robust systems for analysing performance in SQA examinations leading to priorities for improvements and action plans being developed. However, the analysis of young people's performance from S1 to S3 and progress towards achieving a broad general education is less well developed. Departments are often not tracking learners' performance in the sciences compared to their performance in other subjects or are unable to measure value added from S1 to S3. In some secondary schools, there have been clear gender differences regarding the uptake of physics and biology. For example in some schools, biology is predominantly studied by girls at national qualification stages and physics by boys. This is also reflected in national figures (see Appendix 4). In some schools, this has not been a notable feature. Some schools, having recognised this as an issue, had taken proactive measures such as promoting the Women into Science programme. Others have been unaware of this issue despite comprehensive examination analysis. A few schools have recognised this as an issue but have as yet taken no positive action to address this, with no relevant priorities appearing on their improvement plan.

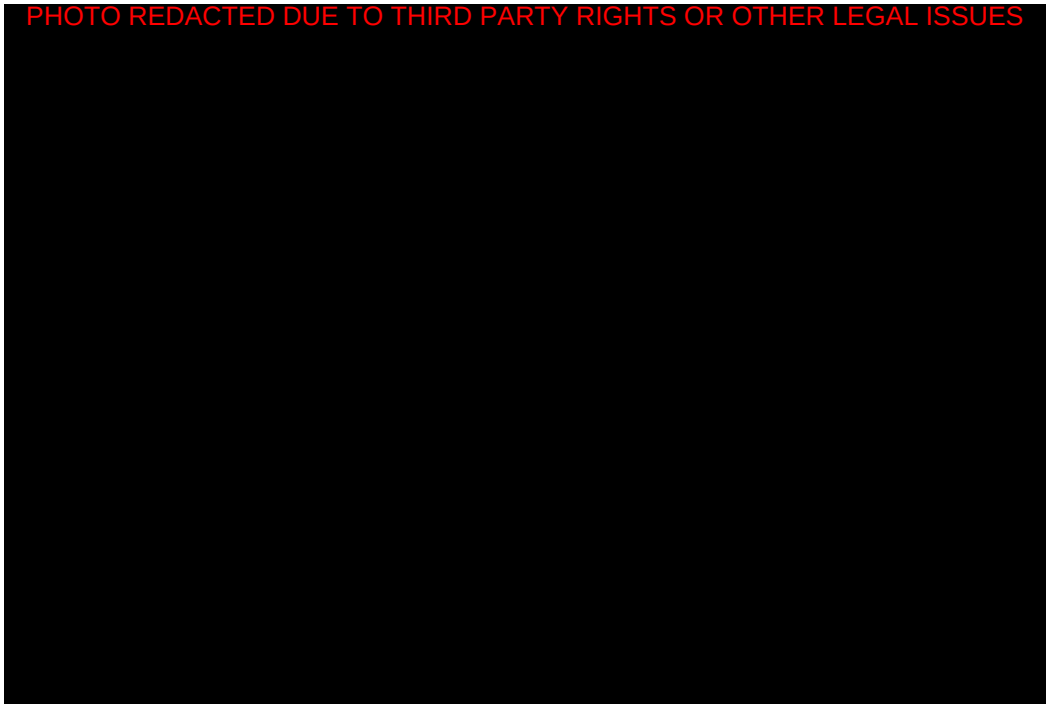
Primary schools and special schools are generally not tracking children's performance in the sciences sufficiently well. They are often unable to show evidence of children's progress and achievement in the sciences. Recently advice and guidance on assessing progress and achievement of the broad general education has been published and further work in this area is planned to support practitioners.

Primary schools and secondary science departments are increasingly seeking learners' views and taking them into account. For example, making changes to learning programmes such as introducing more open-ended investigations into programmes in response to pupil voice. However, this is not a consistently strong feature across the country.

Good Practice Example 39

One sciences department identified through their self-evaluation a need to develop further the leadership skills of senior pupils and raise the profile of pupil voice. A group of senior pupils studying sciences at Higher, Advanced Higher and for the Scottish Baccalaureate in Science held a regular lunchtime 'science pupil forum'. Young people across various stages dropped into lunchtime sessions to make suggestions for improvements and provide feedback on learning programmes within the broad general education and the senior phase. A science pupil forum noticeboard was maintained regularly by young people keeping others abreast of discussions and impact of their work.

All schools sampled were making progress with implementing Curriculum for Excellence. However, the progress was variable across the country. Schools continue to develop plans on how they were going to progress implementation of the sciences element of the broad general education. Secondary schools continue to review plans for their senior phase and discussing articulation of the broad general education with the senior phase. Recent advice and guidance on this has been published in Curriculum for Excellence Briefings 6, 7 and 8.



Career long professional learning

Professional learning communities provide a context within which teachers can engage in collegiate and collaborative learning. This is a key feature of a strengthened model of professional learning which, in turn, leads to learning which is embedded, sustained and relevant and with a greater and more positive impact on teachers, children and young people. There has been an overall positive shift towards increased collegiate working in recent years across all sectors. Teachers more often use non-class contact time to discuss and share ideas, experiences and resources with each other. In the best examples of collegiate working, there is often a strong climate of self-evaluation and a commitment to improving outcomes for learners. The strong ethos of collegiality observed in several schools helped to generate opportunities for effective professional learning. Staff were comfortable in sharing their strengths and identifying areas for development. Teachers are increasingly supporting each other and sharing practice across classes in primary schools. Secondary staff are increasingly doing this with colleagues within the sciences department and/or across departments. In a number of sciences departments visited for the purpose of completing this report, teachers of different discrete sciences were sharing good practice very well and supporting colleagues in delivering new learning programmes in areas of the curriculum in which they were less confident. Staff are increasingly sharing and developing good practice by visiting colleagues in other schools and at times visit colleagues in a different sector. This is not yet a consistent feature of good practice across schools.

The professional learning needs of teachers are usually identified within school and education authority quality assurance and improvement planning processes, including professional review and development. Needs are generally identified through self-evaluation by individual teachers, and in the best practice, through response to feedback from learners, peer observers, line managers and quality improvement officers. The rigour of this process is not yet consistent across all schools and authorities. The General Teaching Council for Scotland (GTCS) have developed a suite of standards to support self-evaluation within professional learning. These include the Standards for Registration, Standard for Career-long Professional Learning and Standards for Leadership and Management. As teachers progress through their careers, the standards will help them to identify, plan and develop their professional learning needs and ensure continuing development of professional practice. Thought will have to be given as to how staff can develop their skills to meet new standards published by The General Teaching Council for Scotland. For example, staff will in the future need to, “know how to work with the local and global community to develop realistic and coherent interdisciplinary contexts for learning, particularly in relation to sustainability.”

Teachers can now undertake an increasingly varied range of professional learning activities, including experiential learning provided by external providers, self-directed personal reading or research and learning through use of ICT. High-quality online resources can provide an excellent basis for self-directed learning. There is an increasing use of Glow, the national education intranet, to enhance professional development and some effective online learning communities have resulted.

Using the video contact facilities, Glow can be used to share practice across classrooms which is in line with recommendation 40 from *Teaching Scotland's Future (2010): 'Online CPD should be part of the blended, tailored approach to CPD for all teachers.'*

Professional learning communities and action learning sets have given teachers and other professionals an opportunity to develop and share practice in a collegiate and collaborative context. Some teachers have described valuable professional learning activities through participation in curriculum development groups, subject groups and special school groups to take forward thinking and developments at school, cluster, authority and national levels. Some have participated in activities relating to assessment and development of the new national qualifications. Some teachers have found participation in moderation activities valuable but these activities as yet have not often had a focus on the sciences. Undertaking courses leading to qualifications, accreditation or professional recognition has proven to be a successful professional learning activity for a number of teachers. Examples include the post graduate certificate in primary science. Masters-level professional learning is advocated as an appropriate standard for all teachers. Masters level includes characteristics from the Scottish Credit and Qualifications Framework (SCQF) Level 11 which provides a benchmark for planning and delivery of professional learning. A few teachers described valuable work experience placements which they undertook in industrial settings. These opportunities developed teachers' skills and enhanced their career awareness which they could pass on to learners.

Good Practice Example 40 - **New to this updated version of the report**

A cluster of sixteen schools worked collaboratively over a three year period to develop learning and teaching in the sciences. The aim of their partnership working was to support primary/secondary transition; provide a progressive, cohesive sciences experience for all children and young people; and build staff confidence in teaching the sciences. A teacher from the associated secondary school and one from each of the primary schools were allocated time to work together to produce a progressive sciences programme. They used Education Scotland's STEM Central contexts as the basis for planning progressive learning. The planning took account of skills development and opportunities for assessment across the significant aspects of learning in the sciences. The suggested contexts provided an approach (using engage, explore, explain, elaborate and evaluate) for staff to work collaboratively and flexibility for teachers to develop their own learning narratives. Working together teachers produced a number of suggested rich tasks outlining progression from early to third level, a skills progression framework, a sciences glossary and a helpful teachers' guide. Practitioners from across the cluster were provided with an opportunity to engage with the new resources at an all-staff cluster engagement event and have begun to use them in planning learning. Teachers felt that as a result of this partnership working, they better understood the standards for learning in the sciences and felt they would be more confident than they would otherwise have been in working with other colleagues to share developments. The cluster schools will continue to collaborate to extend the approach they have developed to incorporate technologies, engineering and mathematics as well as sciences. This cluster approach will now be disseminated to other schools in the education authority.

Many staff from the pre-school, primary and special schools sectors still report a lack of confidence in teaching the sciences. This highlights the need to provide all staff with appropriate science-specific professional learning from initial teacher education and throughout their teaching careers. There are a range of professional learning providers across the country including universities, specialist providers, associations and national bodies. There is a need to ensure that all contributors to teacher professional development are enabled to play the fullest possible part in the continuing professional development of all staff.

Good Practice Example 41 - New to this updated version of report

One of the national science centres working in partnership with Mills Observatory provided professional learning and networking opportunities for teachers in the primary and secondary sectors along with student teachers. Using funding from the Association of Science and Discovery Centres and Science and Technology Facilities Council, and linking with the STEM Ambassadors scheme, practitioners had opportunities to consider how to work with partners in a meaningful way to plan rich learning and teaching for children and young people. With a focus on learning opportunities associated with World Space Week, practitioners considered issues relating to published work including the Sciences 3-18 Curriculum Area Impact Project report, Assessing Progress and Achievement of Levels in the Broad General Education (Sciences) and Primary Science Process and Concept Exploration research to consider approaches to learning and teaching science inquiry for first and second level. Delegates explored a range of practical activities developing skills, including literacy and numeracy, and are able to use learning journeys along with a 'loan box' of equipment with learners in the classroom. This partnership approach also offers opportunities to plan visits to the Science Centre and Mills Observatory as part of planned learning and teaching to participate in relevant workshops and activities.

One of the prominent providers of professional learning in the sciences is the Scottish Schools Education Research Centre (SSERC) in partnership universities, professional bodies, educational organisations and industry. SSERC is a shared service amongst the 32 Scottish local authorities. In addition to its advisory service in science and technology, the centre provides targeted professional learning to improve subject knowledge and skills of mainly primary and secondary teachers, curriculum leaders and technical support staff. The professional programmes are offered in a range of formats that vary from interactive electronic sessions, short face-to-face sessions to immersive one or two-part residential events. Their experiential, practical professional learning sessions enable teachers to gain hands-on experience, refresh and deepen their own scientific knowledge and understanding, as well as develop materials, resources, and relevant teaching approaches. Participating teachers report benefiting from such high-quality professional learning. The Scottish Government has committed to three years of funding for 2012 – 2015 for SSERC to ensure teachers have access to their valued professional learning programme. This includes ring-fenced funding to raise the confidence of primary teachers in delivering science education. The funding will enable continuity and evolution of the programmes of professional development that have been in place since 2007.

Good practice Example 42 - New to this updated version of the report

A series of inspection reports highlighting weaknesses in sciences provision prompted one education authority to make the sciences an improvement priority for its schools. Science was included in the authority's performance framework which in turn encouraged schools to incorporate it as a priority within their improvement plans. This raised accountability for sciences at school level. It organised sciences professional learning for teachers, some of which took place over a week long period in the summer break period. This has been offered in partnership with the local science centre and a variety of visiting speakers have provided an array of high-quality presentations and workshops to support teachers in developing their confidence, knowledge and skills. These programmes of activities have been well attended and evaluated positively by teachers. They have reported increased levels in confidence in teaching the sciences. A number of schools in the education authority have participated in the Primary Science Quality Mark project.

The education authority has reported significant progress in the sciences across primary schools over the three year period. The achievements and progress of schools were celebrated through high-profile showcase events.

The broadening range of professional learning themes and approaches described as being experienced by teachers is predominantly focused on aspects which were related to Curriculum for Excellence, for example the promotion of collaborative learning approaches, formative assessment and the use of ICT to improve learning. The provision of science-specific professional learning is uneven across the country.

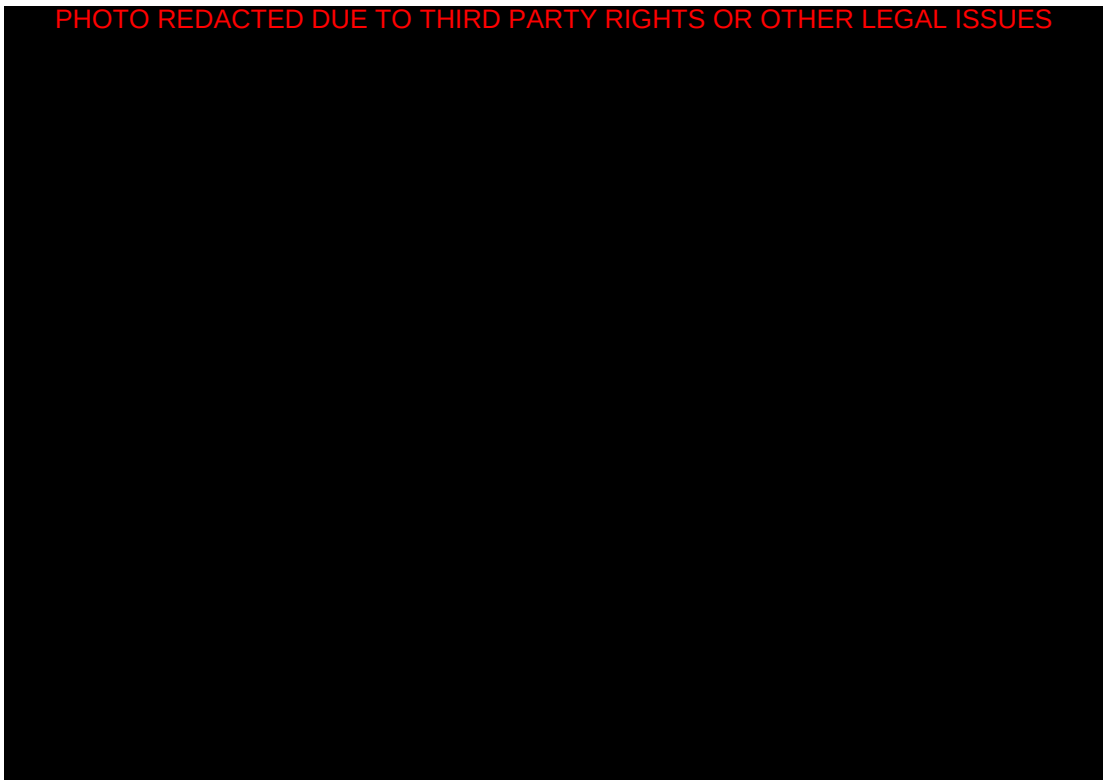
Some barriers to accessing valuable professional learning reported include:

- being situated in a remote location with accompanying costs becoming prohibitive;
- being unable to attend some external events due to the lack of supply cover;
- budget cuts having led to a reduction of the number of activities offered through authority professional learning catalogues; and
- the demise of education authority science advisers resulting in less focus on science-specific professional learning at authority level.

Good Practice 43 - New to this updated version of the report

A group of practitioners from a rural cluster participated in the first year of the Primary Cluster Programme in Science and Technology which is being piloted by the Scottish Schools Education Research Centre (SSERC). SSERC has been able to provide ongoing support for the cluster through effective interactive use of Glow using the Glow Meet facility. This has helped to overcome distance as a barrier and has also enabled a large number of teachers from all the schools involved to access the experiential professional learning being offered by SSERC. SSERC also offers interactive Glow Meets on a variety of topics which are open to all primary practitioners. Prior to each Glow Meet, the school receives a box of resources containing materials that will be used in activities to be carried out during the Glow Meet. Up to 20 schools can participate in each Glow Meet, with several practitioners attending per school. Participating practitioners work through the activities that support learning and teaching in the sciences in real time along with the SSERC Glow Meet tutor, before using them in the classroom.

There is a need to ensure that all staff involved in teaching the sciences have access to high-quality science-specific professional learning related to their development needs. This is particularly important as the education profession continues to implement Curriculum for Excellence and at a time where teachers in secondary schools are becoming familiar with a range of new national qualifications.



Summary

The following points highlight what we do well and what we need to continue to improve in the sciences 3-18 in Scotland. They will help practitioners to reflect on Scotland's strong practice and engage in discussions on aspects for development. By using CPD Central practitioners can join a debate about the sciences and share good practice from across the country. They can also share what did not work and help others to avoid the pitfalls.

Key strengths

1. Most children and young people enjoy and are motivated by their learning in the sciences.

2. Across all sectors, staff are becoming increasingly familiar with, and more confident in using the sciences experiences and outcomes in planning for the broad general education.

3. The use of interdisciplinary learning (IDL) which offers opportunities for children and young people to experience learning from different subject and curriculum areas in motivating and relevant contexts is an increasing feature of learning across all sectors.

4. Staff across all sectors are increasingly using the local environment and wider community and are extending partnerships to enhance and support learning well within the sciences. Outdoor learning in particular is emerging as a strong feature of learning in the sciences.

5. Overall in secondary schools, curriculum plans for the senior phase are in place and continue to be reviewed with the sciences continuing to have a central place.

6. Learning and teaching in the sciences in the classroom is continually improving. Much progress has been made in developing and embedding new and improved learning and teaching approaches in everyday educational practice.

7. Most staff are increasingly planning more active learning experiences in the sciences and increasingly using more relevant and innovative contexts for learning.

8. Increasingly, children and young people are engaging in productive collaborative working within the sciences.

9. Overall, most children and young people are progressing well from prior levels of attainment. In the senior phase, the sciences continue to be popular subject choices and most young people are achieving well.

10. Teachers are highly committed to developing the sciences curriculum and improving outcomes for learners. Subject specialists, at the secondary stages in particular, are generally knowledgeable and enthusiastic about their subject area.

11. Increasingly teachers are working collegiately and supporting each other through professional learning activities such as engaging in professional dialogue and sharing good practice.

Aspects for development

1. Staff across all sectors need to ensure that all children and young people's entitlement to a broad general education is being met. The sciences element of the broad general education is currently not always successfully contributing to achieving this.

2. Children and young people are not often enough experiencing sufficient depth in their learning across all key areas in the sciences. One contributing factor is insufficient awareness of *Sciences: Concept development in the sciences (2009)* paper.

3. In primary schools, learning in the sciences is too often predominantly or exclusively delivered through an interdisciplinary approach which is not planned sufficiently well to ensure breadth and to develop children's knowledge and skills in a progressive way.

4. Stronger curricular links between pre-school centres and primary schools and between primary and secondary schools should be developed further to build effectively on children and young people's prior experiences and to ensure continuity in learning.

5. Secondary schools need to continue to review their plans for the senior phase and ensure that learning at the broad general education phase articulates well with their senior phase.

6. Staff in secondary schools need to recognise and act on gender imbalance in physics and the biologies where it exists.

7. Staff should ensure that feedback to children and young people is regular and of a high enough quality to make them aware of their strengths and what they need to do to improve their learning.

8. Schools need to continue to develop approaches to assessing, tracking and reporting on progress in the sciences.

9. There is a need to ensure that all staff involved in teaching the sciences have access to high-quality science-specific professional learning related to their development needs. There is a need to increase early years, primary and special schools staffs' confidence in particular in teaching the sciences.

10. More primary schools need to make development of the sciences a key priority in their improvement plan.

Appendix 1 - List of establishments visited

Thank you to the following schools who engaged so positively with HM Inspectors to provide much of the evidence for this report.

Pre-school Centres

Baker Street Nursery, Stirling Council
Clentry Nursery School, Fife Council
Clyde Cottage Nursery Centre, Argyll and Bute Council
Early years provision at Dens Road Primary School and Nursery Class, Dundee City Council
Grassmarket Nursery, Edinburgh City Council
Hollandbush Nursery, South Lanarkshire Council
Renfrew Street Nursery School, Glasgow City Council
Tarbolton Nursery, South Ayrshire Council

Primary Schools

Achiltibuie Primary School, Highland Council
Borestone Primary School, Stirling Council
Croftfoot Primary School, Glasgow City Council
Dens Road Primary School and Nursery Class, Dundee City Council
Girvan Primary School, South Ayrshire Council
Glengowan Primary School, South Lanarkshire Council
Hatton (Cruden) School, Aberdeenshire Council
Howdenburn Primary School, Scottish Borders Council
Millersneuk Primary School, East Dunbartonshire Council
Newbigging Primary School, Angus Council
Shiskine Primary School, North Ayrshire Council
Sidlaw View Primary School, Dundee City Council
Sikeside Primary School, North Lanarkshire Council
St John Bosco Primary School, Renfrewshire Council
St Mark's Primary School, East Renfrewshire Council

Secondary Schools

Aberdeen Grammar, Aberdeen City Council
Balwearie High School, Fife Council
Boroughmuir High School, Edinburgh City Council
Castlemilk High School, Glasgow City Council
Cathkin High School, South Lanarkshire Council
Dumfries High School, Dumfries and Galloway Council
Grange Academy, East Ayrshire Council
Johnstone High School, Renfrewshire Council
Kilwinning Academy, North Ayrshire
Larbert High School, Falkirk Council
Lornshill Academy, Clackmannanshire Council
Morgan Academy, Dundee City Council
Oban High School, Argyll and Bute Council
Perth High School, Perth and Kinross Council
St Aidan's High School, North Lanarkshire Council
St Ninian's High School, East Dunbartonshire Council

Special Schools

Croftcroighn Primary School, Glasgow City Council
Drummond School, Highland Council
Park School, East Ayrshire Council
Willowbank School, North Lanarkshire Council

Appendix 2 - Links to useful resources

Education Scotland web-based resources

The Journey to Excellence is a professional learning resource incorporating videos highlighting thought-provoking and innovative learning and teaching. There are numerous videos with the sciences as a focus including:

Developing skills, knowledge and understanding: Deans Community High School
Science teacher: Milngavie Primary School
Developing the sciences across the authority: East Dunbartonshire
Building the Science curriculum: Millersneuk Primary School
The Excellence awards - an interdisciplinary project: Deans Community High School
Science across the school - Early Level: Strathallan Primary School
Science across the school – P7: Strathallan Primary School
Science across the school: Strathallan Primary School
Real Life Science - Watching the birdies: Pilrig Park School
Real Life Science - In the salon: Pilrig Park School
Real Life Science - Growing enterprise (tatties): Pilrig Park School
Skills progression: Bearsden Cluster
Science literacy: Bearsden Cluster
Increasing confidence in science: Strathallan Primary School
Biodiversity - chicken(s) and the egg: Poppies Nursery
Building staff confidence: Poppies Nursery
Embedding science in the life of the nursery: Poppies Nursery
Parents sharing expertise: Poppies Nursery
Environmental benefits: Balfron High School
Formative assessment: Penicuik High School
From Plant to Plate: Netherlee Primary School
Future Engineers: Forth Valley College
Interactive and rewarding Science: Queensferry Primary School
Maths in Motion
Meeting learning needs in science (learning and teaching)
New ways of expanding young minds in science
Numeracy across the Curriculum
Rainforest recipes: Bargeddie Primary School
Science: A portrait of good practice Conference Film
Science Investigation
Science News Hounds: Greenock Academy
Taking Learning Outdoors – Science
Wolves Lesson

Other resources to support learning and teaching in the sciences include:

Curriculum for Excellence: Sciences: Concept Development in the Sciences (Learning and Teaching Scotland, 2009)
Curriculum for Excellence: Sciences Experiences and Outcomes (Learning and Teaching Scotland, 2009)
Curriculum for Excellence: Sciences Principles and Practice (Learning and Teaching Scotland, 2009)
STEM Central: Engineering through sciences, technologies and maths
Twig on Glow
Exploring Climate Change

Schools' Global Footprint
Weather and Climate Change
Professional focus papers for national qualifications
Glow – national qualification course materials
Inspection advice note (2012-2013)
Curriculum for Excellence national expectations: self-evaluation resource QI 5.1 & QI 5.9
Assessing progress and achievement in the sciences
Planning around the experiences and outcomes
Monitoring and tracking progress and achievement in the broad general education
Curriculum for Excellence briefing series

The GTC Scotland Professional Standards
Curriculum for Excellence: Building the Curriculum 2 – Active Learning in the Early Years (Scottish Executive, 2007)
Curriculum for Excellence: Building the Curriculum 3 – A Framework for Learning and Teaching (The Scottish Government, 2008)
Curriculum for Excellence: Building the Curriculum 4 – Skills for Learning, Skills for Life and Skills for Work (The Scottish Government, 2009)
Curriculum for Excellence: Building the Curriculum 5 – A Framework for Assessment (The Scottish Government, 2011)
How good is our school? The Journey to Excellence (HMIE, 2006)
Improving Scottish Education: A report by HMIE on inspection and review 2005-2008 (HMIE, 2009)
Learning Together: Improving Teaching, Improving Learning (HMIE, 2009)
Quality and improvement in Scottish education: Trends in inspection findings 2008-2011(Education Scotland, 2012)
Review of the Contribution of the Scottish Science Centres Network to Formal and Informal Science Education (HMIE, 2007)
Science: A portrait of current practice in Scottish Schools (2008)
Scottish Qualifications Authority: External Assessment Reports (see subject areas)
Assessment at Transition Report (University of Glasgow, 2012)
Excellence in Science Education: Report from the Science Excellence Group, Science and Engineering Education Advisory Group (The Scottish Government, 2011)
Reviews of National Policies for Education: Quality and Equity of Schooling in Scotland (OECD, 2007)
Programme for International Student Assessment (PISA) 2009 Key Findings (OECD, 2009)
PISA 2009 Results: What Students Know and Can Do: Student Performance in Reading, Mathematics and Science (Volume 1) (OECD, 2010)
A Science Strategy for Scotland (Scottish Executive, 2001)
Science & Engineering 21 – Action Plan for Education for the 21st Century (The Scottish Government, 2009)
Science and Mathematics Education, 5-14 A 'State of the Nation' Report (The Royal Society, 2010)
Science for Scotland: A Strategic Framework for Science in Scotland (The Scottish Government, 2008)

2008 Scottish Survey of Achievement, Mathematics and Core Skills (The Scottish Government, 2009)

2007 Scottish Survey of Achievement (SSA) Science, Science Literacy and Core Skills, (The Scottish Government, 2008)

Skills for Scotland: A Lifelong Skills Strategy (The Scottish Government, 2007)

Supporting Scotland's STEM Education and Culture, Science and Engineering Education Advisory Group Second Report (The Scottish Government, 2012)

Teaching Scotland's Future: Report of a review of teacher education in Scotland (The Scottish Government, 2010)

The Government Economic Strategy (The Scottish Government, 2007)

TIMSS 2007 International Science Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grade (TIMSS & PIRLS, International Study Centre, Boston College, 2008)

Trends in International Mathematics and Science Survey – Highlights from Scotland's Results (The Scottish Government, 2008)

Scotland's Environment Website

Appendix 3 - Links to useful organisations

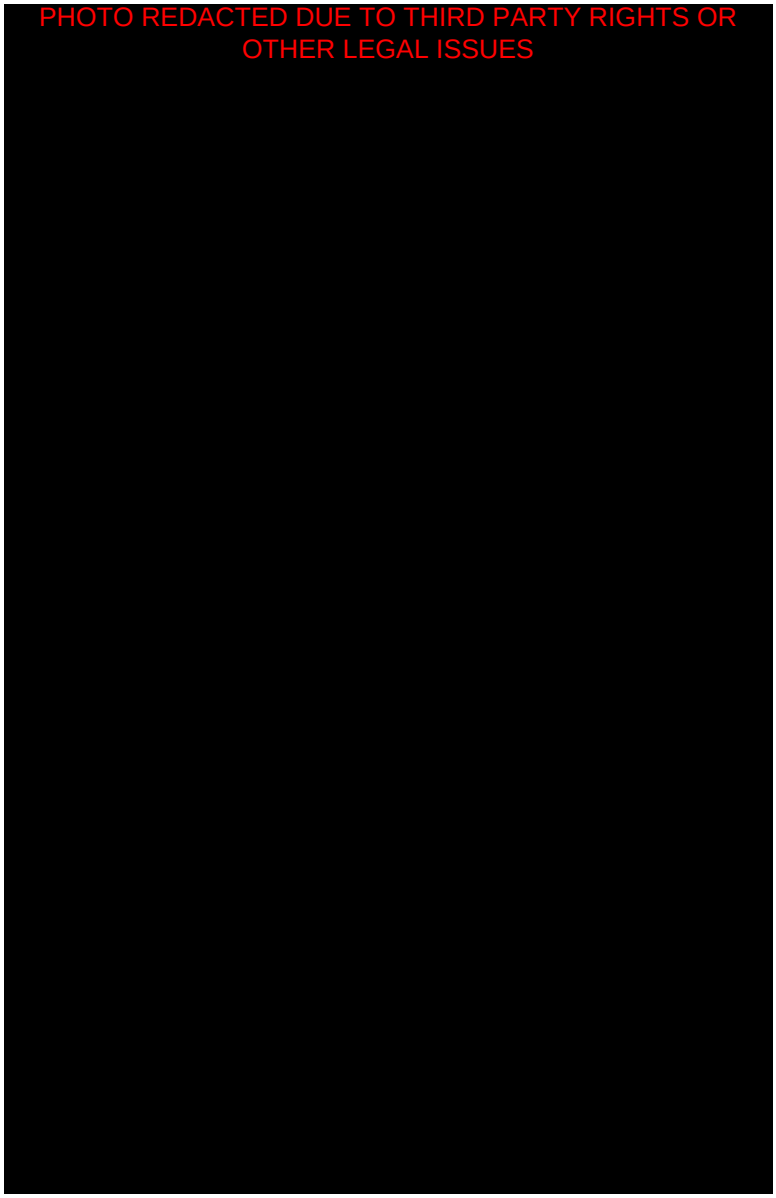
There are numerous organisations associated with education in the sciences in Scotland. Below is a sample. This is not intended to be an exhaustive list.

Education Scotland
Scottish Qualifications Agency (SQA)

Botanic Gardens Glasgow
British Geological Survey
British Science Association
The Conservation Volunteers (Scotland)
Dundee Botanic Garden
Dundee Science Centre
Earth Science Education Unit
Eco-Schools Scotland
Edinburgh International Science Festival
Energy & Utility Skills
Engineering Development Trust (EDT)
Engineering the Future (EtF)
English Speaking Union (ESU)
Forestry Commission
Generation Science
GeoBus
Glasgow Science Centre
Glasgow Science Festival
Grounds for Learning
The James Hutton Institute
The Lighthouse, Glasgow
Moredun Research Institute
National Trust for Scotland
Opito - The Oil and Gas Academy
Our Dynamic Earth
Rowett Institute of Nutrition and Health
Royal Botanic Garden Edinburgh
Royal Society for the Prevention of Cruelty to Animals
Royal Society for the Protection of Birds
The Salters' Institute
Satrosphere
Scottish Association for Marine Sciences (SAMS)
Scottish Council for Development and Industry
Scottish Earth Science Education Forum
Scottish Environment Protection Agency (SEPA)
The Scottish Science and Technology Roadshow SCI-FUN
Scottish Science Education Research Centre (SSERC)
Scottish Stem Cell Network (SSCN)
The Sector Skills Council for Science, Engineering and Manufacturing Technologies (SEMTA)
Skills Development Scotland

STEMNET (STEM Ambassadors)
TechFest-SetPoint
Young Engineers and Science Clubs Scotland

The Association for Science Education (ASE)
Institution of Civil Engineers (ICE)
The Institution of Engineering and Technology (The IET)
Institute of Physics (IOP)
Royal Society of Chemistry
Royal Society of Edinburgh



Appendix 4 - Statistical information

Some results in awards by the Scottish Qualifications Authority (SQA) within the Scottish Credit and Qualifications Framework (SCQF) for the period 2009 to 2013 are shown below. These results relate to presentations by secondary schools in Scotland (i.e. excluding presentations by special schools or colleges, but including presentations by independent secondary schools and all-through schools). The percentages quoted for uptake and attainment are calculated using the total number of young people who were entered for at least part of the course at that subject at that level and includes those who did not achieve an overall course award. The results shown for 2012 represent pre-appeal information. The percentages quoted for Higher level at S5/6 for 2012 and 2013 are an amalgamation of Higher and Revised Higher data.

Results for the period 2009-2013

- At S3-S4 at Standard Grade, on average, around 57% of young people presented for biology, chemistry and physics achieved SCQF level 5, grades 1-2 (Credit) and around 89% achieved SCQF levels 4 and 5, grades 1-4 (Credit and General). Only around 13% of young people presented for Standard Grade Science achieved grades 1-2 (Credit) and around 74% achieved grades 1-4 (Credit and General).

- At S3-S6 at Access 3, SCQF level 3, performance had generally improved in the five year period with on average 95% in biology, 91% in chemistry, 83% in physics and 91% in MER achieving an award.

- At S3-S6 at Intermediate 1, SCQF level 4, the average percentage of young people achieving A-C grades was 68% in biology, 74% in chemistry and 68% in physics and overall had improved in the five year period. In MER, performance was variable in the same period with on average 70% achieving A-C grades.

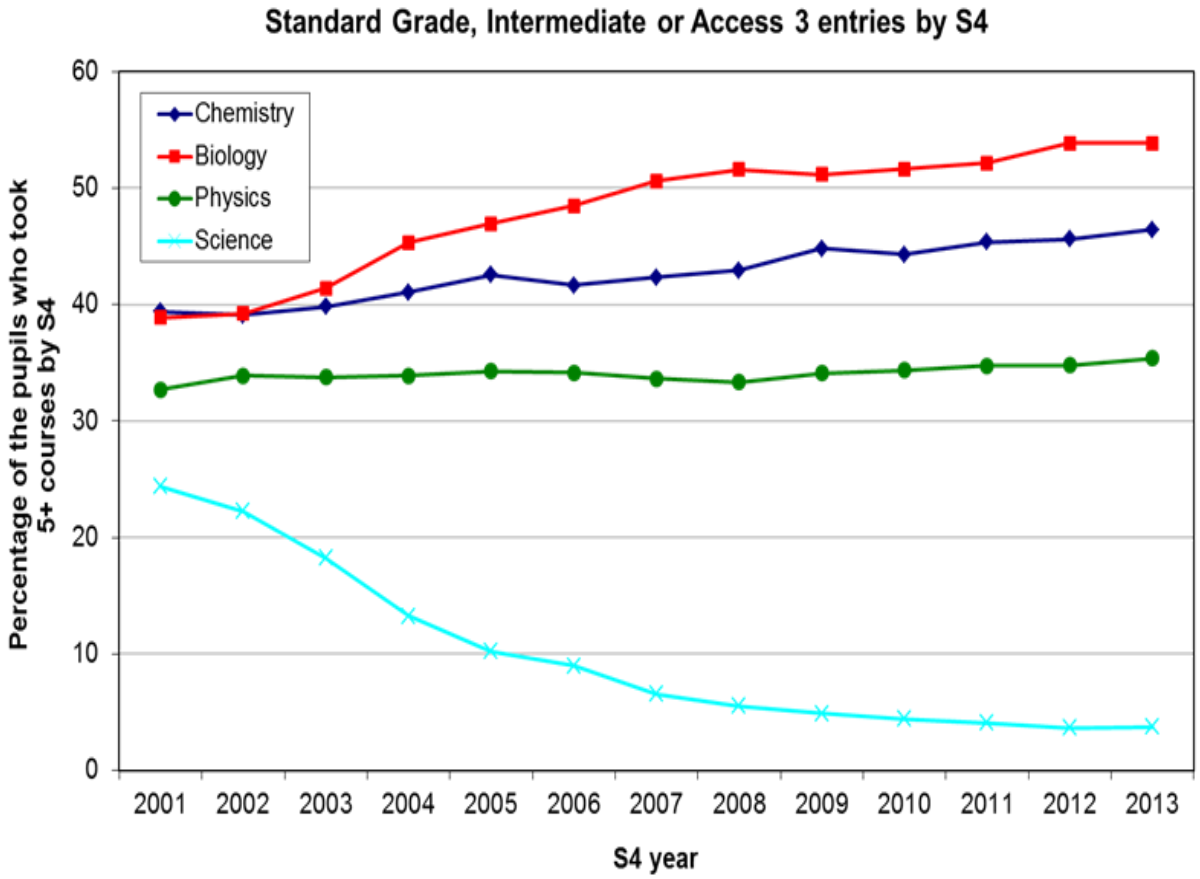
- At S3-S6 at Intermediate 2, SCQF level 5, on average 71% in biology, 78% in chemistry and 73% in physics achieved A-C grades. In biotechnology, on average 65% achieved A-C grades with on average 71% in managing environmental resources (MER).

- At S5/S6 at Higher, SCQF level 6, the percentage of those presented achieving A-C grades had improved slightly in biology (71%), chemistry (78%) and in physics (77%) over the five year period. The same improving trend is not evident in human biology with on average 71% achieving an A-C grade over the same period.

- At S5-S6 performance at Advanced Higher, SCQF level 7, was consistently strong with around 78% of young people presented achieving A-C grades.

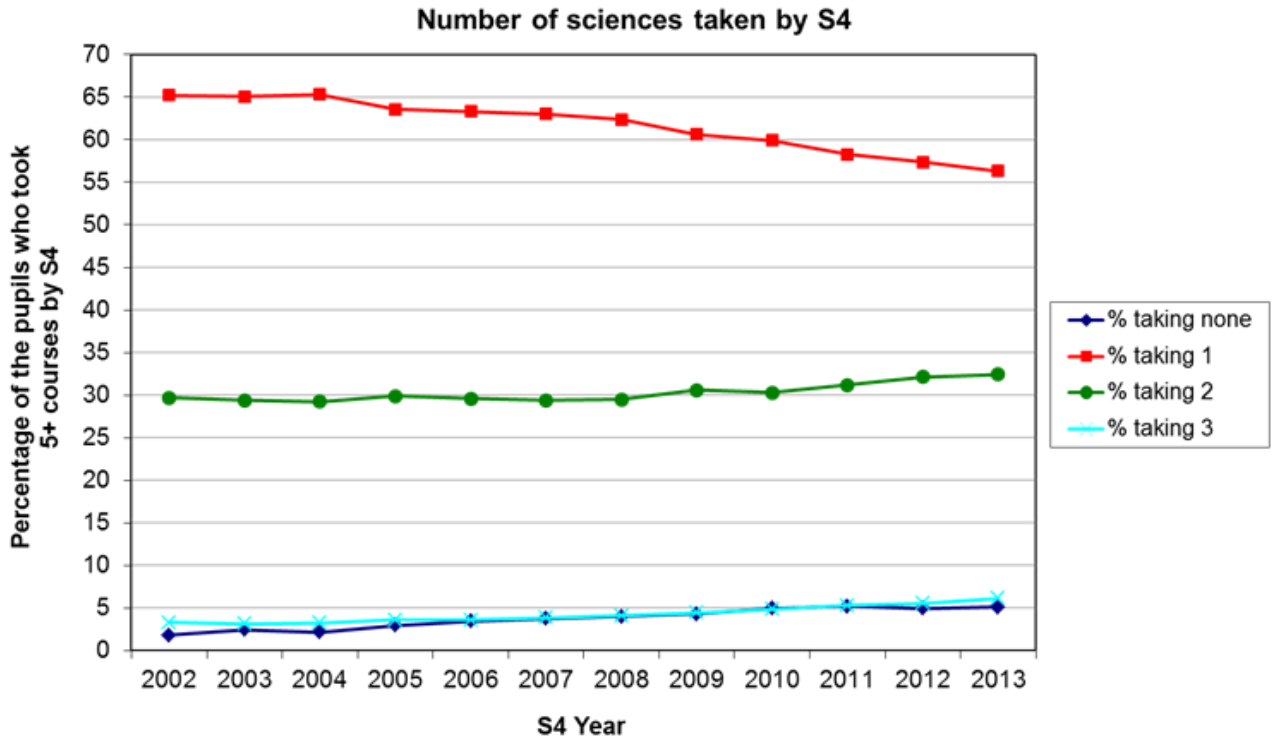
Uptake by S4

The three main sciences subjects are currently the 3rd, 5th and 8th (biology, chemistry and physics respectively) most popular subjects studied by S4 when considering the proportion of pupils taking five or more courses by S4 roll taking the subjects at Access 3, Intermediate 1 or 2, or Standard Grade. Standard Grade science has dropped considerably over recent years from 16th in 2002 to 25th in 2012 a fall of 83%.



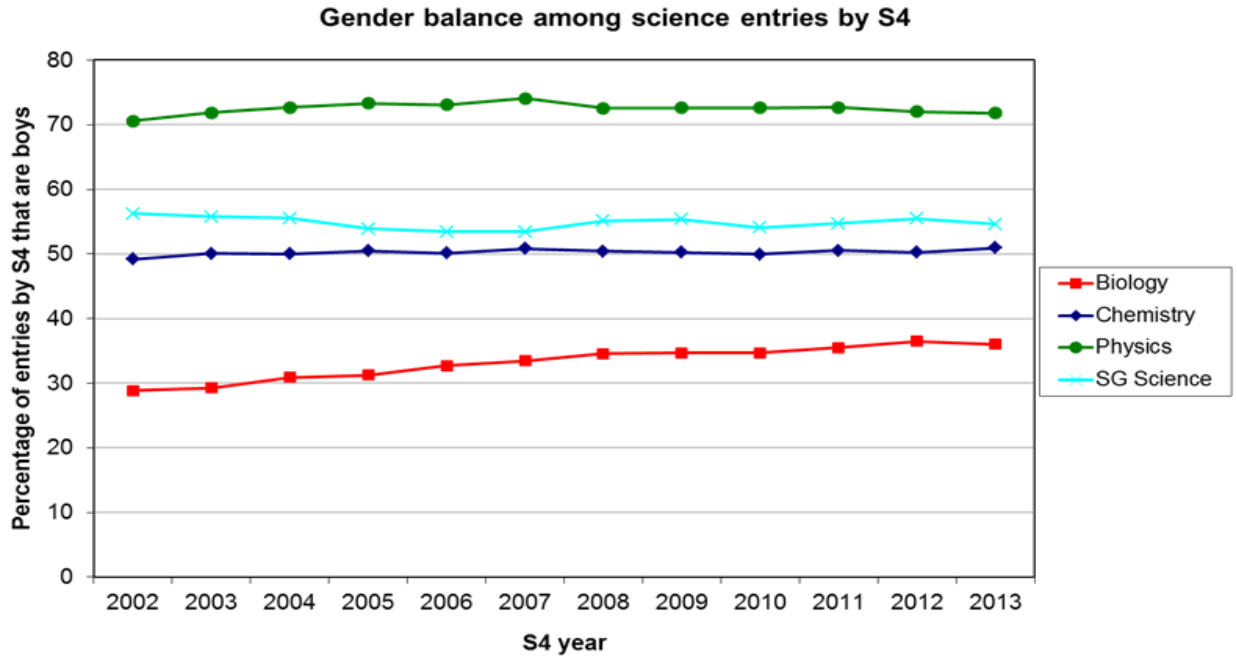
Although chemistry accounts for 35% of entries in the three main sciences at Standard Grade and Intermediate 2 by S4, it only accounts for 21.2% of entries among those taking only one of the three main sciences. Chemistry is more often taken as a second science to either physics or biology than on its own. Physics and biology is the least popular combination.

There is an increase in the proportion of pupils taking two, or three science subjects by S4. In 2002, 3.3% of S4 pupils taking five or more courses by S4 took three or more science subjects. In 2012, 6.2% did. In 2002, 29.7% of S4 pupils taking five or more courses by S4 took two exactly two science subjects, in 2012 32.4% did.

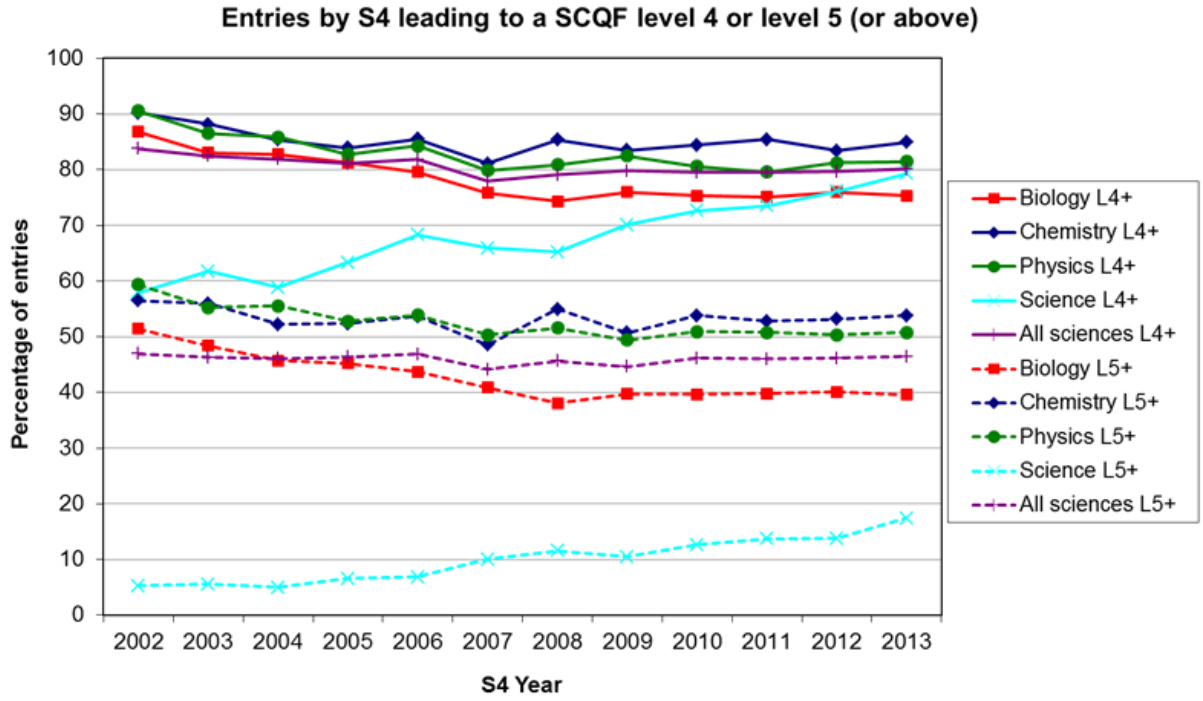


Gender differences in uptake by S4

In the last decade, physics courses by S4 have been taken consistently by a higher proportion of boys. Although the proportion of boys studying biology courses by S4 over the last decade has been increasing, there is a notably higher proportion of girls taking these courses. There is no notable gender difference with chemistry and science.



Attainment by S4



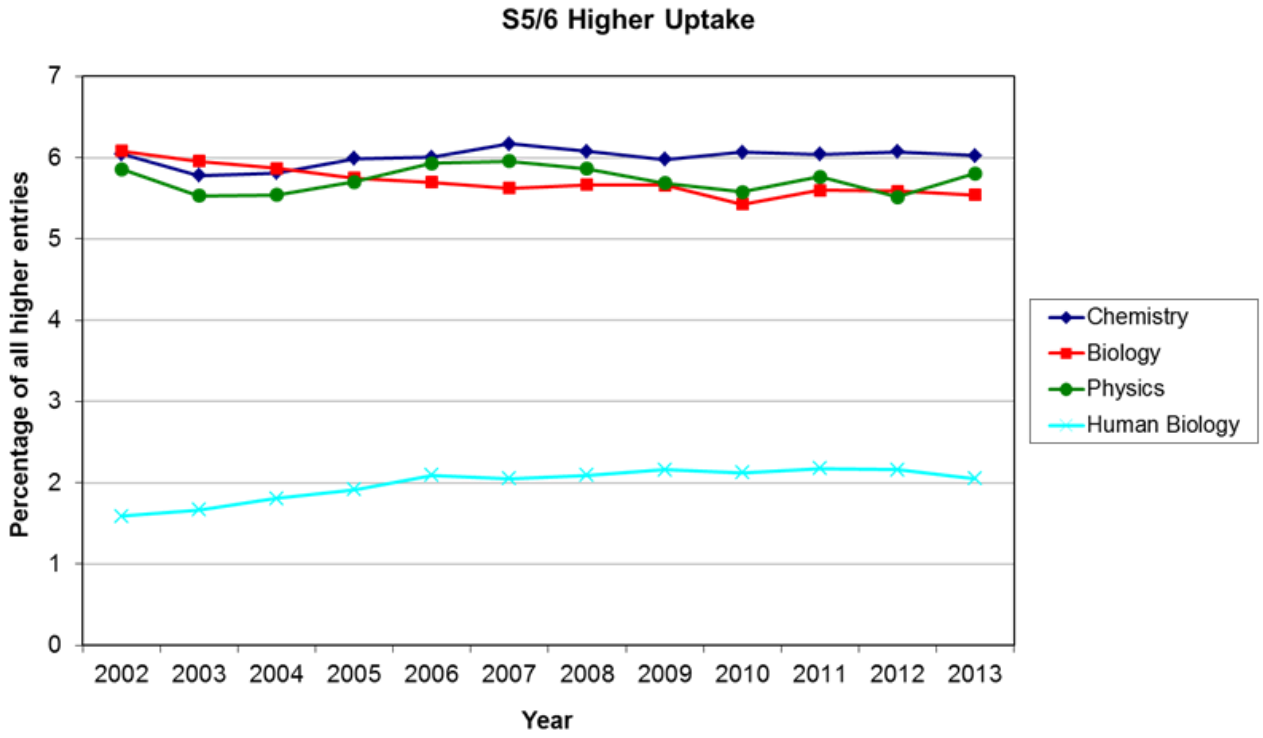
Progression from S4 to S5

Of the ten most popular subjects studied at S4, physics and chemistry have the highest proportion of pupils going on to study at Higher level in S5 other than mathematics and English. Over the past ten years 59% of credit physics pupils went on to Higher in S5 in 2011 and 53% in chemistry. Biology also has a high proportions progressing with 44% of Credit biology pupils going on to Higher at S5.

This is similar for progression from Intermediate 2 to Higher. Whilst 91% of those achieving A or B in English went on to Higher at S5 in 2011, 72, 74 and 73% of those in mathematics, physics and chemistry respectively do so. Biology also shows a high progression figure from A or B at 60%.

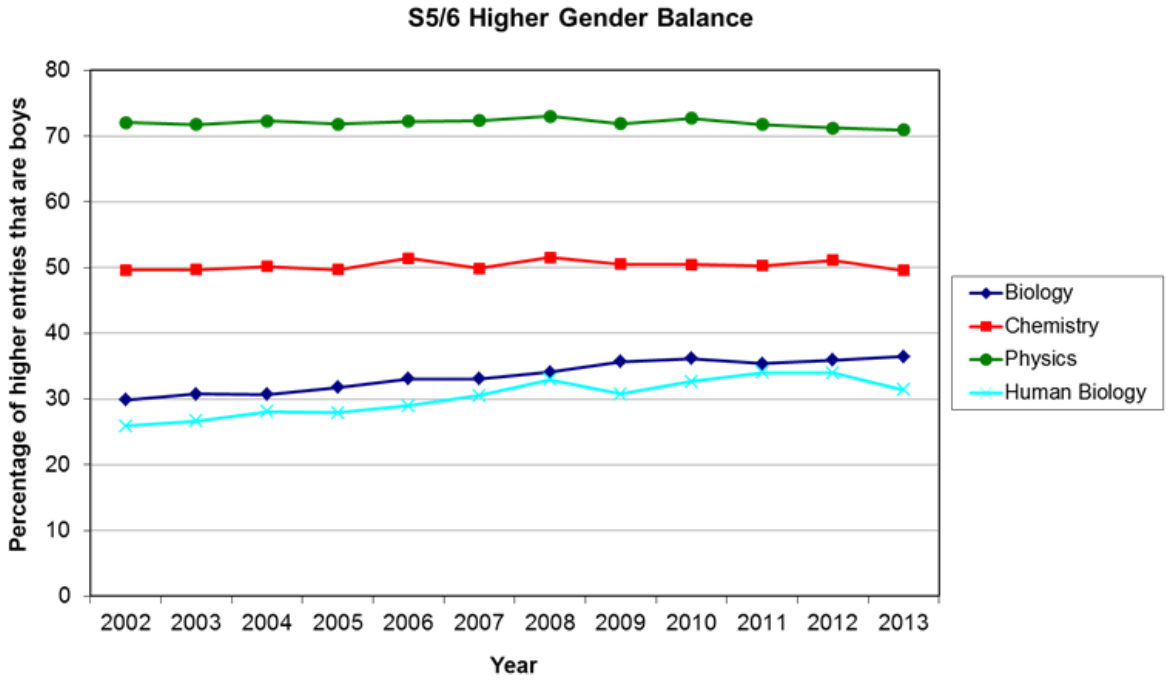
Uptake at S5/6

The three main science subjects have consistently been very popular at Higher level at S5/6. With the exception of 2012 where history overtook physics and biology, the three main sciences have consistently featured in the five most popular subjects studied. The proportion of young people studying human biology at Higher level has increased steadily over the past decade.



Gender differences in uptake at S5/6

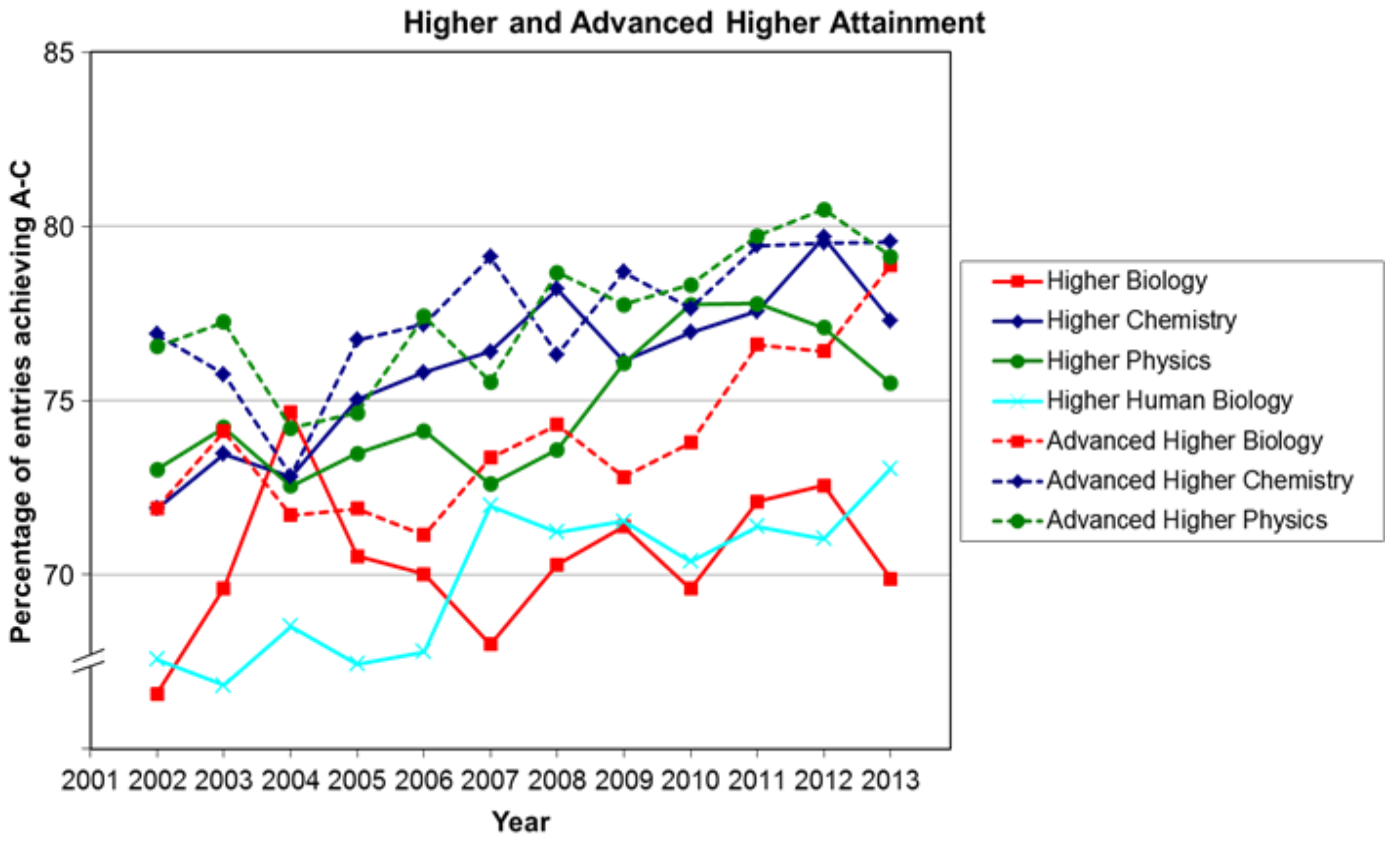
Over the past decade a consistently higher proportion of boys have taken Higher physics. Although the gender balance in Higher biology and Higher human biology is improving, notably a consistently higher proportion of girls have taken these subjects over the last decade. Chemistry shows no such gender difference.



Attainment at Higher and Advanced Higher at S5/6

Attainment in chemistry and physics at Higher level has been strong and has been generally improving over the last decade. Attainment in biology and human biology is not as strong but has generally been improving over the last decade.

Attainment in the three main sciences at Advanced Higher level is generally in line with other that of other subjects. Attainment at Advanced Higher physics is stronger than that in the other sciences.



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