

Sciences Curriculum Background and Evidence Paper

March 2026

Executive summary

Overview

This paper provides an evidence base to inform the ongoing Curriculum Improvement Cycle (CIC) for sciences¹ in Scotland. It draws on national and international data, academic research, and stakeholder perspectives to support curriculum improvement and help shape a modern, inclusive, coherent and research-informed sciences curriculum for all learners aged 3-18.

Main considerations

The main considerations for the CIC process for sciences are outlined below.

- There are a significant number of Scottish Government policies and strategies which relate to science, many of which focus on sustainability, climate change, nature and biodiversity.
- Labour market information shows that scientific skills are key to many economic sectors in Scotland, including health care, construction and green jobs.
- The range of sciences qualifications and senior phase pathways on offer needs to be reviewed to ensure they meet the needs of learners, FE/HE, employers and society. Parity of esteem of different pathways should be part of this consideration.
- With some exceptions, pass rates at National 5, Higher and Advanced Higher for sciences in 2024 were generally lower than 2019 levels, especially at Advanced Higher level. SQA course reports identified literacy levels and practical knowledge as significant factors affecting attainment.
- Between 2019 and 2024, there has been an upward trend in STEM-based entries in other qualification pathways (including Skills for Work, National Progression Awards, National Certificates and Foundation Apprenticeships) which shows schools are broadening their offer.
- The PISA (2022) study shows an overall decline in average scores for science in Scotland since 2006, reflecting declining performance globally. Scotland's [mean score](#) in science in 2022 (483) was similar to the OECD average (485), and similar to the 2018 score (490).
- International reports and frameworks highlight the need for scientific understanding and science as the producer of reliable knowledge in the 21st century when humanity faces an uncertain future and in the face of a concerning rise in deliberate misinformation and disinformation.
- Inspection and thematic reports from His Majesties Inspectorate of Education (HMIE) offer limited insight into science and STEM learning due to Quality Indicator 2.2 (Curriculum), not considered to be core. Evidence that does exist suggests better

¹ Scotland's Curriculum for Excellence outlines key concepts for the [Sciences broad general education \(BGE\)](#) (ages 3-15) using five organisers: Planet Earth; Forces, electricity and waves; Biological systems; Materials; Topical science. They each show progression across four levels. In the senior phase (ages 15-18), there are many pathways for sciences but broadly speaking science can be considered to include National Qualifications in Biology, Human Biology, Chemistry, Physics, Science and Environmental Science. Other pathways science departments may offer include Skills for Work courses such as Laboratory Science and Health Sector. For a more detailed overview, refer to the ['Defining STEM' document](#).

integration of sciences and mathematics, development of scientific language skills and real-world relevance could improve engagement.

- Numerous data sets and evaluations exist from Education Scotland examining:
 - Barriers to and engagement with STEM learning and subjects.
 - Practitioner confidence and professional learning needs.
 - Separate evidence points to challenges and lack of confidence in the teaching of science and STEM in early learning and childcare and primary sectors, and also a reduction of technician numbers and insufficient funding as detrimental to student outcomes in secondary schools.
 - Sciences education has a large number of stakeholders (including partner organisations and professional learning providers), who contribute positively to the sciences educational experience. This includes recognising achievement and providing exciting experiences for learners.
 - In recent publications, the Learned Societies (Royal Society of Biology, Royal Society of Chemistry and Institute of Physics) have recommended a big ideas approach to science education and share similar views on the core purposes of science education.
 - Learners have called for a curriculum that focuses on climate change, looking after the planet, outdoor learning, equalities, health and wellbeing and having their rights upheld, all of which are closely linked to Learning for Sustainability. They want their learning experience rooted in the real world and applied in context. Both learners and parents, are keen for children and young people to have opportunities to engage with businesses, participate in work experience and to learn more about STEM careers.
 - Academic research demonstrates the importance of science as dynamic and contextual. Science identity is complex and intertwined with societal representations of science. Science has a significant role to play in addressing the uncertainty we face as a nation and globally. Lastly, a range of pedagogies are appropriate to sciences learning and teaching.
 - Future trends highlight a range of challenges facing society which will disproportionately affect children and young people. A future-oriented education system offers opportunities to tackle these.
 - There are gaps in the evidence around the provision of sciences in a number of areas, for example, the challenges around teaching of science in additional support needs settings, on the role and importance of technicians in delivering sciences education and the teaching of sciences and STEM in early learning and childcare settings.
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1 Introduction

1.1 Purpose

This paper offers a snapshot of the current educational landscape, drawing on a diverse range of research and evidence to illuminate prevailing trends, challenges, and successes across contexts. It serves as a foundation for ongoing curriculum development, offering insights into the policy environment, learner experience, and professional perspectives. By incorporating both qualitative and quantitative data, it creates space for reflection and informed discussion. While not all available studies are included, those selected reflect the breadth of work currently shaping thinking in this area. The insights outlined here are intended to support Curriculum Improvement Cycle (CIC) stakeholder groups as they consider key issues and navigate the next steps in the evolution of the curriculum.

1.2 Sources of evidence

A comprehensive body of research was gathered through a collaborative effort involving representatives from Education Scotland's Curriculum, Learning, Teaching and Assessment (CLTA) team; the Data, Performance and Research (DPR) Team; Scottish Government Analytical Services and the Scottish Government Library Support Service. This collaboration brought together a wide range of expertise to support the identification, evaluation, and organisation of relevant literature. The sources drawn upon include, but are not limited to, peer-reviewed academic papers, His Majesty's Inspectorate of Education publications (HMIE), Scottish Qualifications Authority (SQA) and Achievement of Curriculum for Excellence Level (ACEL) data analysis, surveys, government data sets, research produced by national agencies, Scottish Government reports, and international publications from organisations such as the OECD and the United Nations. Additionally, the perspectives of children and young people are represented through the work of bodies such as the Children's Parliament and the Children and Young People's Commissioner Scotland.

1.3 Scope of the review

This paper examines Scotland's curriculum across the full 3–18 learner journey, considering the range of educational experiences, learning progression, and outcomes from early level through to the senior phase. Acknowledging that this journey begins at around age 3, the early level spans early learning and childcare (ELC) settings (such as nurseries and childminders), and extends into Primary 1 and beyond for some children. Its role is foundational, shaping the experiences, skills, and dispositions that underpin future learning and development. By considering the curriculum as a continuous and coherent pathway from early childhood to young adulthood, this evidence paper reflects the full spectrum of a learner's experience. This paper focuses on the sciences curricular area as outlined within Scotland's Curriculum for Excellence (CfE).

Scotland's CfE outlines key concepts for the [Sciences broad general education \(BGE\)](#) (ages 3-15) using five organisers: Planet Earth; Forces, electricity and waves; Biological systems; Materials; Topical science. They each show progression across

four levels. In the senior phase (ages 15-18), there are many pathways for sciences but broadly speaking science can be considered to include National Qualifications in Biology, Human Biology, Chemistry, Physics, Science and Environmental Science. Other pathways science departments may offer include Skills for Work courses such as Laboratory Science and Health Sector. For a more detailed overview, refer to the [‘Defining STEM’ document](#). The paper highlights key policy drivers and educational practices that support the development of scientific knowledge and understanding for all learners. It reflects on learning and achievement in the broad general education, drawing on national indicators such as senior phase attainment including National Qualifications, and National Progression Awards (NPAs) amongst others. The paper aims to support a holistic understanding of the current curricular landscape, highlighting key themes and emerging patterns that will inform ongoing discussion and decision-making through the Curriculum Improvement Cycle process.

1.4 Related national policies

The documents listed below detail Scottish Government policies relevant to the sciences curriculum.

[STEM education and training strategy](#) (Scottish Government, 2017)

The STEM education and training strategy aims to build a strong base of STEM skills and knowledge for everyone by encouraging people to develop more specialised STEM skills and capabilities. The strategy sets out the actions for the education and training system, the science engagement sector, and for community learning and development (CLD) which will help address these issues from 2017 – 2022. It outlines four long-term outcomes:

1. All learners experience relevant and engaging STEM learning.
2. There is equality of access.
3. People are well equipped to undertake job roles which require STEM knowledge and skills.
4. Scotland has a STEM workforce, leadership and research base which supports economic growth, innovation, creativity and increased productivity.

[STEM education and training strategy: Refresh](#) (Scottish Government, 2022)

The challenges and opportunities facing STEM education and training, initially identified in the 2017 STEM Strategy, remain broadly similar in 2022. The refresh document outlines adapted outcomes:

1. Efforts should continue to ensure children, young people and adults are encouraged to develop an interest in, and enthusiasm for, all aspects of STEM.
2. Ensure that our education and training system has the right number and diversity of practitioners to deliver high quality learning and teaching.
3. Education and training offer should be flexible and responsive to ensure citizens are equipped with skills required.
4. Continuing at pace to tackle gender imbalances and other inequalities that exist across STEM education and training.

[Learning for Sustainability \(LfS\) Action Plan 2023 to 2030](#) (Scottish Government, 2023)

Scotland's Learning for Sustainability Action Plan 2023 to 2030 "Target 2030: A movement for people, planet and prosperity", aims to build an inspiring movement for change so every 3 to 18 place of education becomes a sustainable learning setting by 2030. The new action plan builds on the previous Vision 2030+ Action Plan (2019), and is informed by the research projects carried out by the [University of Dundee](#) and [Children's Parliament](#).

The strategy contains five key themes and associated actions:

- leadership and collaborative partnership
- curriculum, learning, teaching and assessment
- learning environment and resources
- learner voice, choice and action
- meaning and understanding

It outlines the global and national context behind the action plan. It celebrates and builds on Scotland's world-leading approach to sustainability education, but it also recognises and seeks to address the barriers to achieving that vision.

The overall vision lists five targets:

1. All learners should have an entitlement to Learning for Sustainability.
2. In line with the new General Teaching Council Professional Standards, every practitioner, school and education leader should demonstrate Learning for Sustainability in their practice.
3. Every setting should have a whole setting approach to Learning for Sustainability that is robust, demonstrable, evaluated, and supported by leadership at all levels.
4. All settings' buildings, grounds and policies should support Learning for Sustainability.
5. A strategic national approach to supporting Learning for Sustainability should be established.

[Climate Emergency Skills Action Plan](#) (Skills Development Scotland, 2020)

Climate education and an understanding of natural capital needs to form an integral part of all education and skills training and work-based learning through continued commitment to outdoor learning as a key part of Learning for Sustainability. This action plan seeks to ensure that natural capital and circular economy considerations are recognised as core skills across all disciplines. It also encourages the use of Developing the Young Workforce Regional Groups and school co-ordinators to embed green skills in schools.

There are many other Scottish Government policy strategies, which are too numerous to list in detail. These are very pertinent to the review of the sciences curriculum. For example, [climate change adaptation plan](#), [biodiversity and nature emergencies](#), [net](#)

zero, green industrial strategy, energy and just transition, circular economy, marine science, space, food and drink, historic environment and engineering. All policies mentioned set out the key areas of employment and skills required in Scotland's future and are also relevant when considering what needs to be included in a future science curriculum. The high number of strategies linked to sustainability, climate change, nature and biodiversity demonstrate that the sciences curriculum has a big part to play in creating citizens who care, who have the knowledge and skills to succeed in jobs, of now and the future, and to become responsible citizens.

For further information, please see these links to relevant policies and strategies.

- [A Blue Economy Vision for Scotland](#) (2022)
- [Carbon Neutral Islands Action Plans](#) (2022/23)
- [Climate change: Scottish National Adaptation Plan 2024-2029](#) (2024)
- [Circular Economy \(Scotland\) Act 2024](#) and [draft strategy](#)
- [Climate Change \(Emissions Reduction Targets\) \(Scotland\) Bill, \(2024\)](#)
- [Climate change: Scottish National Adaptation Plan 2024-2029 \(Children's version of adaptation plan](#) also available) (2024)
- [Commission for the land-based learning review: report to Scottish Ministers](#) (2023)
- [Draft Energy Strategy and Just Transition Plan](#) (2023)
- [Green industrial strategy](#) (2024)
- [Marine science and innovation strategy](#) (2024)
- [National innovation strategy 2023 to 2033](#) (2023)
- [Net Zero and Sustainability Framework for Action](#) (2022)
- [Scotland's National Strategy for Economic Transformation](#) (2022)
- [A strategy for space in Scotland](#) (Space Scotland, 2021)
- [Tackling the Nature Emergency - Scottish biodiversity strategy to 2045](#) (2023)
- [Vision for sustainable aquaculture](#) (2023)

And, at UK level:

- [The Economics of Biodiversity: The Dasgupta Review](#) (Dasgupta, 2021)
- [The UK's Modern Industrial Strategy 2025 - GOV.UK](#) (UK Government, 2025)

All policies mentioned set out the key areas of employment and skills required in Scotland's future and are also relevant when considering what needs to be included in a future sciences curriculum. The high number of strategies linked to sustainability, climate change, nature and biodiversity demonstrate that the sciences curriculum has a big part to play in creating citizens who care, who have the knowledge and skills to succeed in jobs of now and the future and to become responsible citizens.

The following are less science specific but are important for education more broadly. There are numerous reports and policies pertinent to education, and we have tried to include those most relevant to curriculum and reform.

[All Learners in Scotland Matter – national discussion on education: final report](#)
(Scottish Government, 2023)

For learners, climate change and environment are at the centre of their interest and focus for education. The environment that children and young people will inherit is clearly of major and pressing concern. Outdoor learning is another important feature of Scottish education and something respondents felt should be expanded. Rights, as well as understanding and respecting all forms of diversity and equality, should be integrated in the curriculum and curriculum-linked resources, for example understanding and appreciation of race, gender, sexual orientation, disabilities, poverty, and other protected characteristics. Preparing children and young people for a future Scotland will be very important where jobs, career pathways, and life choices will be fluid and unpredictable. Learners will also have to be prepared for jobs that don't yet exist – transferrable skills, therefore, become essential. Technology will outpace educational reform and learners indicated they wished to gain information/skills digitally. Educating Our Future requires a Scottish education system that is proactive, flexible, integrated, and upholds the rights of all children and young people.

[Race equality framework for Scotland 2016 to 2030](#) (Scottish Government, 2016)

The framework outlines the need for a renewed focus on supporting learning environments, relationships and curricular content that challenge racial inequality and racism. This is deemed essential if minority ethnic² students are to have a positive early learning and childcare, school and further and higher education experience, without disadvantage. It expresses that racism can be addressed across the curriculum. As part of the response to this, the [Anti-Racism in Education Programme](#) (AREP) was established in 2020 and the group first met in 2021. It continues to ensure commitment to anti-racism in Scottish Education.

This is done via sub-groups focused on:

- [curriculum reform](#)
- [racism and racist incidents](#)
- [diversity in the teaching profession and education workforce](#)
- [education leadership and professional learning](#)

² It is important to note that minority ethnic communities are not a homogeneous group, in the same way that any other group of people that share protected characteristics (eg disability, sex, sexual orientation) will not all have the same experience of discrimination. For the purposes of the AREP, 'minority ethnic' includes anyone with a racialised identity (both visible and non-visible). 'Racialised identity' is a term which reflects the process of society placing people in set categories and the subsequent negative effects of that categorisation. It is important to note that language around anti-racism frequently changes.

Part of this work included publishing a set of [anti-racist principles](#) which focus on children and young people's experience in particular, and provide key points that can help embed anti-racism in a new and contemporary curriculum.

The curriculum reform sub-group recommends that:

- It is not only schools with Black and minority ethnic pupils who need to be doing this (anti-racism) work.
- Teachers should be better equipped to respond to current events (recent racism on social media and elsewhere towards sportspeople, for example) and acknowledge/address them in the classroom. Accepting that not all practitioners will be equipped to do this, putting processes in place to facilitate the quick dissemination of information might be useful.
- Explicit reference in the CfE Experiences & Outcomes (Es&Os) to anti-racism and black history would signal that something we care about is being prioritised.
- The positive impact/ achievement of Black and minority ethnic people should be highlighted outside of social studies, across every curriculum area and level.

[Putting Learners at the Centre: Towards a Future Vision for Scottish Education](#) (Scottish Government, 2022)

All efforts must be directed to the purposes described in Article 29 UNCRC. Learners see climate change as one of most significant issues facing their futures and must be recognised as a key drive influencing future of education system. There should also be increased recognition of role and value of early years including their approaches to learning and teaching and use of outdoor learning. Scotland is an ethnically diverse society and recognition and celebration of this should be given, along with equal status being given to the voices of those most often unheard, for example, those from different denominations and minority ethnic and Gaelic communities.

Muir also recommends wider pathways for learners and for learning and teaching materials produced centrally to reduce workload on teachers/practitioners. Other suggestions included an improved focus and clarity on documentation; clarity on the role of assessment; standardised testing; teacher judgement; and more. Of particular significance was that clearer metrics on capacities were needed, especially expanding narrow interpretation of successful learners.

[Realising the Ambition: Being Me](#) (Education Scotland, 2020)

Realising the Ambition: Being Me is Scotland's national practice guidance for early years, building on *Pre-Birth to Three* and *Building the Ambition*. It outlines the developmental needs of children from birth to Primary 1 (Education Scotland focus is from age 3 onwards) and emphasises the importance of nurturing relationships, play-based learning, and responsive pedagogy. *Realising the Ambition: Being Me* supports nurseries and other early learning and childcare (ELC) settings by providing a clear, research-informed framework for delivering the early level curriculum in a way that is

developmentally appropriate, child-centred, and responsive to individual needs. The guidance supports continuity across transitions and highlights the foundational role of early learning in shaping lifelong wellbeing and educational outcomes.

[UNCRC \(Incorporation\) \(Scotland\) Act 2024 – part 2: statutory guidance](#)
(Scottish Government, 2024)

The Scottish Government is committed to Scotland being the best place in the world for children to grow up. A central part of our vision is the recognition of, respect for, and promotion of children's rights. These include rights to be treated fairly, to be heard and to be as healthy as possible. Articles most relevant to education include 2, 3, 6, 12, 28, 29, 30, and 31.

[United Nations Convention on the Rights of the Child \(Incorporation\) \(Scotland\) Act 2024](#)

Detail as above. Both are included as one provides guidance, and the other is the legal 'Act.'

These policies provide views and asks from learners as well as highlighting the importance and legal requirement to involve learners in the Curriculum Improvement Cycle process.

2 National data sets

This section outlines the high-level messages from the sciences SQA results 2024. Foundation apprenticeships and non-graded qualifications (such as Skills for Work, National Progression Awards, National Certificates and National 2 to National 4 qualifications) have also been included here for parity of esteem. Higher National Diplomas, Higher National Certificates, Scottish Vocational Qualifications and Professional Development Awards are not included here as these are not commonly delivered by schools. This section also outlines the labour market information for 2034 and the implications this might have for the Curriculum Improvement Cycle. National statistics, including Scottish Government data, are presented. Any additional data sets can be found in section 2.4.

2.1 Scottish Qualifications Authority (SQA) attainment and presentation data

2.1.1 SQA attainment data

The data is provided as descriptions of pass rates and comparisons over a five-year period (2019 – 2024) to illustrate a trend in passes. Unless otherwise stated, pass rates are at grades A-C. This is done firstly for sciences subjects that have SQA examinations (i.e. SQA National Qualifications including National 5, Higher and Advanced Higher), and secondly, looks at pass rates of non-graded subjects (such as Skills for Work Laboratory Science (N5), Health Sector (N5) and other non-graded qualifications).

When considering SQA attainment data it is important to take into account the significant disruption caused to assessments and exams caused by the global COVID-19 pandemic from 2020. This resulted in the introduction of the Alternative Certification Models (ACM), firstly in 2020/21 (SQA, 2022) and then a modified ACM in 2021/22 (SQA, 2023). In 2022, SQA adopted a more generous approach to grading National 5, Higher and Advanced Higher courses than it would do in a normal exam year, to help ensure fairness for learners while maintaining standards. Modifications that had been made to National 5, Higher and Advanced Higher course assessments remained in place for 2022–23 (SQA, 2024k). In 2024, coursework and the assessment of practical skills was re-instated to SQA sciences National Qualifications. In 2024, SQA also returned to established awarding processes and ended the [generous grading approach](#) which had been in place the previous two years to offset the impact of COVID. The impacts of COVID-19 should therefore be kept in mind and year to year comparisons should be treated with caution over this period. Further detail and discussions about performance will be explored in the course reports section below.

SQA National Qualifications (2024) in summary:

- On average, the total number of passes (A-C) for Higher Sciences decreased by 2.0% between 2019 and 2024, from 23,795 (2019) to 23,330 (2024). This includes Chemistry, Physics, Biology and Human Biology.
- For Biology, Human Biology and Chemistry, pass rates (A-C) at Higher in 2024 also decreased compared to 2019 (down 2.0, 4.8 and 1.4 percentage points respectively). The Higher Physics pass rate increased by 0.7 percentage points between 2019 and 2024.
- The pass rates for National 4 and National 5 Biology, Chemistry and Physics decreased across the board between 2019 and 2024. Biology had the most significant decreases with a 6.0% decrease at National 5 level and a 2.4% decrease at National 4 level.
- There were reductions in pass rates in Advanced Higher across all three sciences between 2019 and 2024 with the largest falls in Chemistry (down 11.0 percentage points), Biology (down 7.1 percentage points) and Physics (down 5.8 percentage points).
- For National 5 Environmental Science, the pass rate (A-C) increased by 9.3% between 2019 and 2024. However, there was a decrease in the pass rate of 15.3% for Higher over the same period. Environmental Science is not offered at Advanced Higher. Please note that the uptake for Environmental Science is low so the number of passes can change significantly as a result from year to year and, therefore, should be treated with caution.

A more detailed breakdown by subject for examined qualifications can be found on the [SQA website](#) (2024).

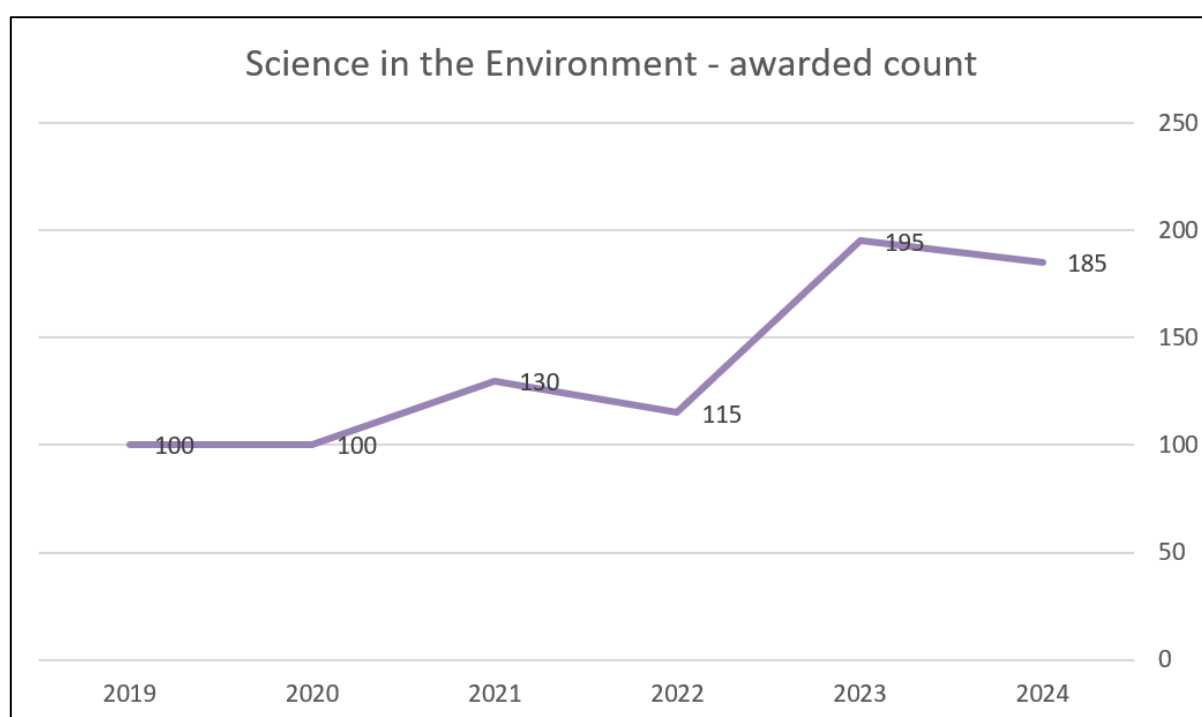
Please note that the percentages above were calculated using the number of awarded counts and entries rather than the percentages listed in the attainment tables.

2.1.2 Non-graded sciences qualifications

For the following graphs, please note that different scales are used so as to best represent the data. All data is taken from the [SQA attainment statistics 2024](#). Awarded count (i.e. the number of passes) is the chosen data set as this was available for all qualifications for ease of comparison. Courses covered here are not exhaustive of all qualifications delivered by sciences educators but include National 2 – National 4 qualifications, Skills for Work, National Progression Awards, National Certificates and Foundation Apprenticeships.

National 2

Only one qualification relating to science is offered at National 2: Science in the Environment. The following graph shows the data in relation to the awarded count since 2019.



Graph 1 - National 2 Science in the Environment - Awarded Count 2019-2024 (SQA)

The awarded count for National 2 Science in the Environment shows an overall increase between 2019 and 2024.

Data

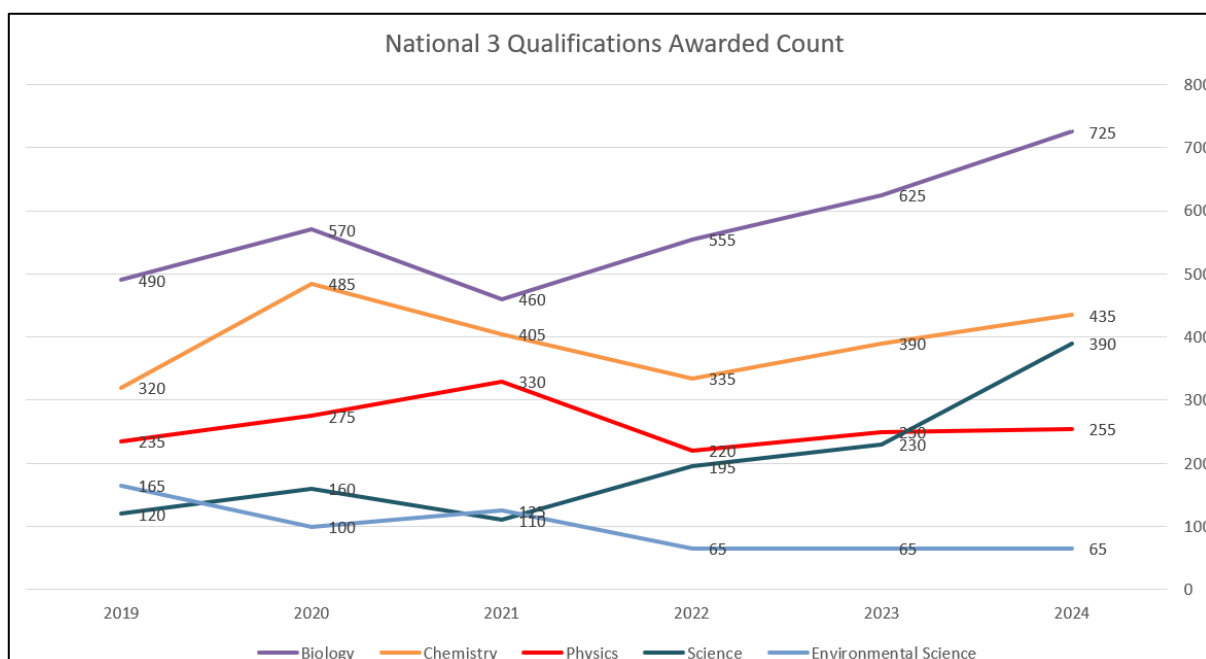
Table 1 - N2 Science in the Environment awarded count and entries (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
	Awarded Count	100	100	130	115	195	185
	Entries	140	125	205	195	270	215

National 3

At National 3, the following sciences qualifications are offered: Biology Chemistry, Environmental Science, Physics and Science.

The following graph shows the awarded count data since 2019.



Graph 2 - National 3 qualifications - Awarded Count 2019-2024 (SQA)

Table 2 - N3 awarded count and entries (2019-2024)

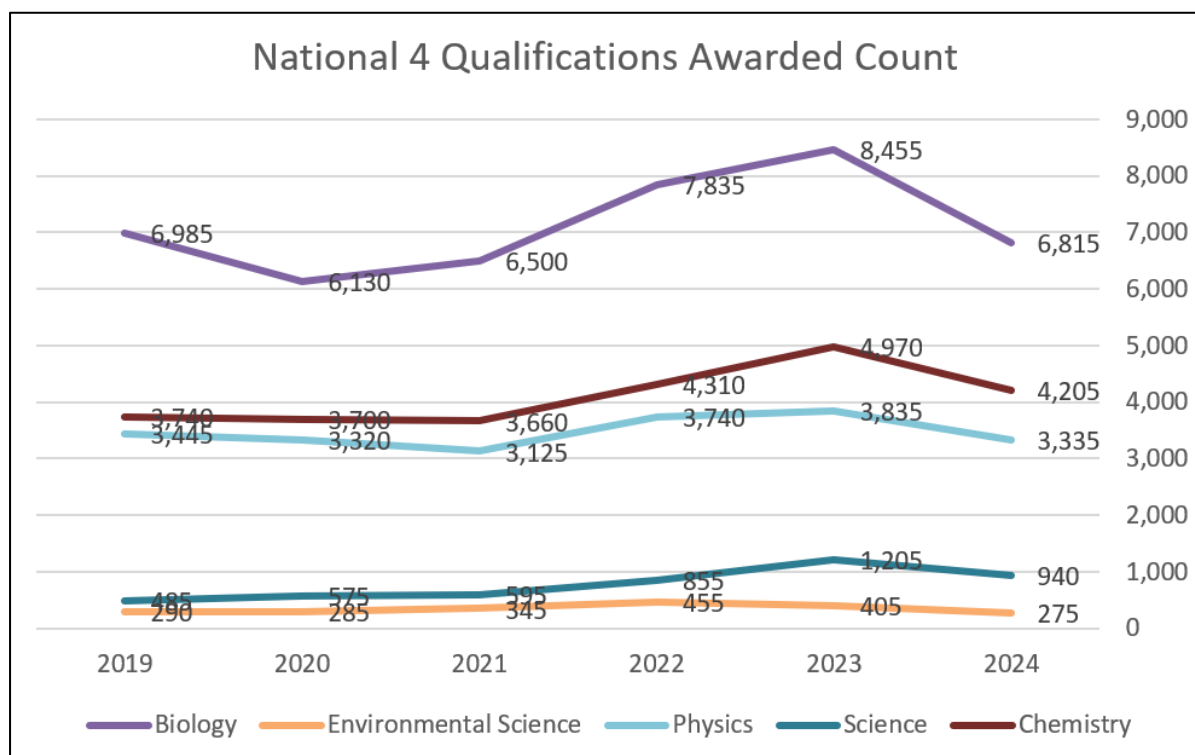
Subject		2019	2020	2021	2022	2023	2024
Biology	Awarded count	490	570	460	555	625	725
	Entries	550	610	550	665	705	865
Chemistry	Awarded count	320	485	405	335	390	435
	Entries	355	520	460	400	430	535
Environmental Science	Awarded count	165	100	125	65	65	65
	Entries	185	105	145	70	80	75
Physics	Awarded count	235	275	330	220	250	255
	Entries	270	305	400	255	280	295
Science	Awarded count	120	160	110	195	230	390
	Entries	155	180	145	235	280	450

Biology shows the highest numbers of passes at National 3 as well as the highest number of entries. Biology, Chemistry, Physics and Science all show upward trends in the number of awarded counts and entries since 2022.

National 4

At National 4, the following sciences qualifications are offered: Biology, Chemistry, Environmental Science, Physics and Science.

The following graph shows the awarded count data since 2019.



Graph 3 - National 4 qualifications - Awarded Count 2019-2024 (SQA)

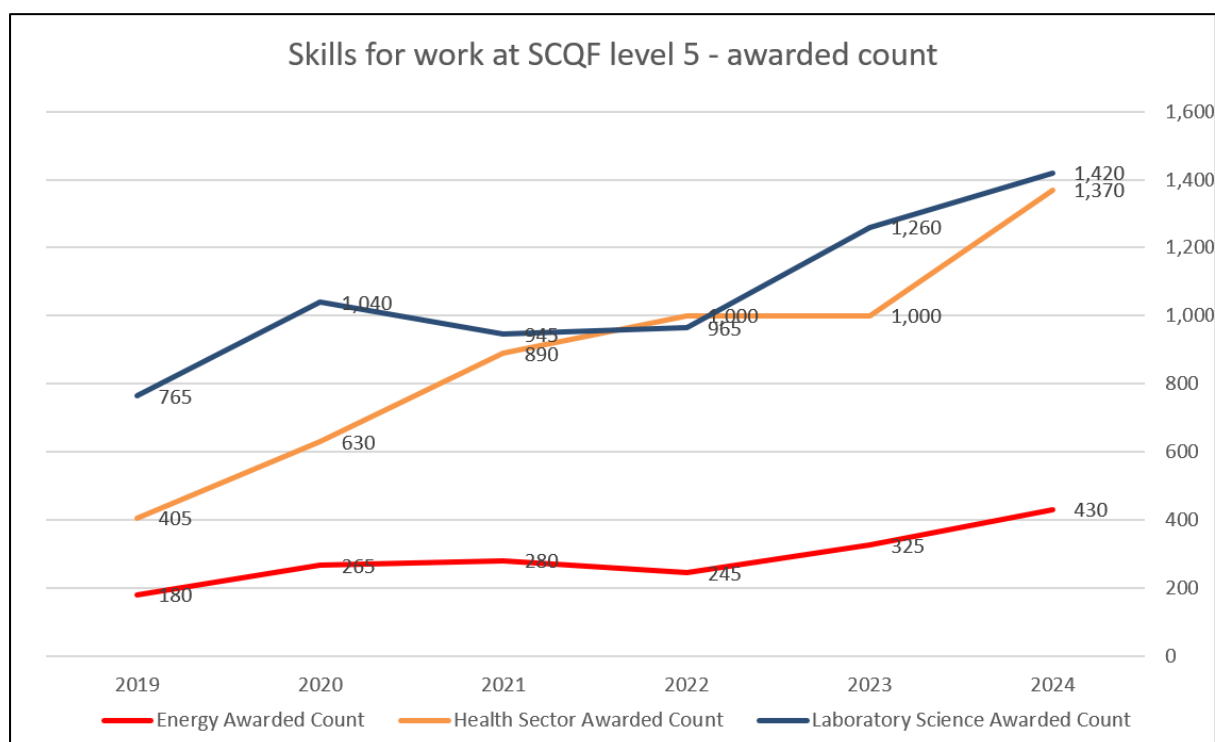
Table 3 - N4 awarded count and entries (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
Biology	Awarded count	6985	6130	6500	7835	8455	6815
	Entries	7525	6480	7045	8510	9165	7535
Chemistry	Awarded count	3740	3700	3660	4310	4970	4205
	Entries	4040	3895	4045	4730	5365	4580
Environmental Science	Awarded count	290	285	345	455	405	275
	Entries	330	320	370	495	440	335
Physics	Awarded count	3445	3320	3125	3740	3835	3335
	Entries	3685	3535	3490	4145	4155	3765
Science	Awarded count	485	575	595	855	1205	940
	Entries	530	685	705	950	1290	1050

As with National 3, Biology shows the highest number of passes and the highest number of entries.

2.1.3 Skills for Work

Skills for Work qualifications include Health Sector (at SCQF Levels 4 and 5), Energy and Laboratory Science at SCQF Level 5. The following graph shows how the awarded count of these qualifications at SCQF Level 5 has changed over time.



Graph 4 - Skills for Work qualifications (SCQF level 5) - Awarded Count 2019-2024 (SQA)

Data

Table 4 - Skills for Work awarded count and entries (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
Energy	Awarded count	190	290	290	275	345	465
	Entries	180	265	280	245	325	430
Health Sector	Awarded count	500	705	1015	1210	1215	1525
	Entries	405	630	890	1000	1000	1370
Laboratory Science	Awarded count	840	1165	1125	1185	1525	1565
	Entries	765	1040	945	965	1260	1420

One possible explanation for the upwards trends shown is that more schools are offering a wider range of sciences qualifications to better suit their learners' needs and interests. There is a similar upward trend for the Health Sector qualification at SCQF Level 4.

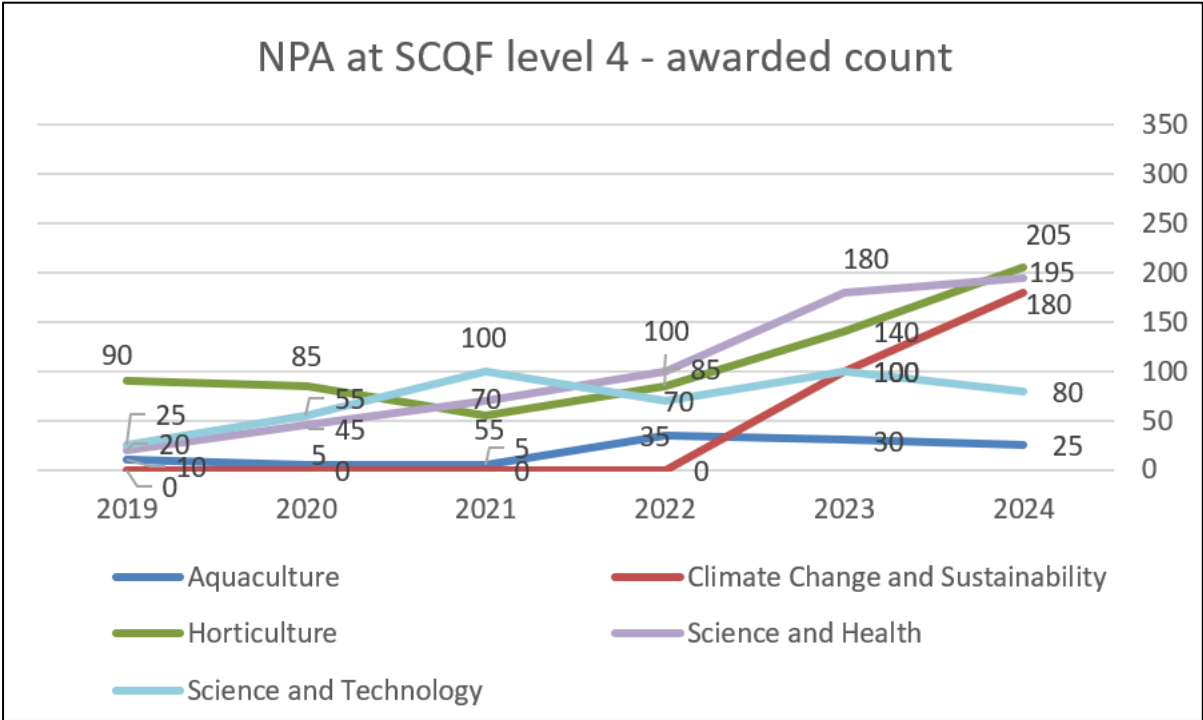
2.1.4 National Progression Awards (NPA)

The most common National Progression Awards with relevance to the sciences include:

- *SCQF Level 3 and 4: Climate Change and Sustainability*
- *SCQF Level 4: Aquaculture, Horticulture, Science and Health, Science and Technology*
- *SCQF Level 5: Aquaculture, Applied Sciences, Practical Science, Rural Skills*
- *SCQF Level 6: Laboratory Science, Scientific Technologies*

The following set of graphs show how the awarded count of these has changed over time. One possible explanation for the upwards trends shown is that more schools are offering a wider range of sciences qualifications to better suit their learners' needs and interests. Please note, only awarded count is available for these qualifications and the numbers of entries is not included.

SCQF Level 4



Graph 5 - NPA qualifications (SCQF level 4) - Awarded Count 2019-2024 (SQA)

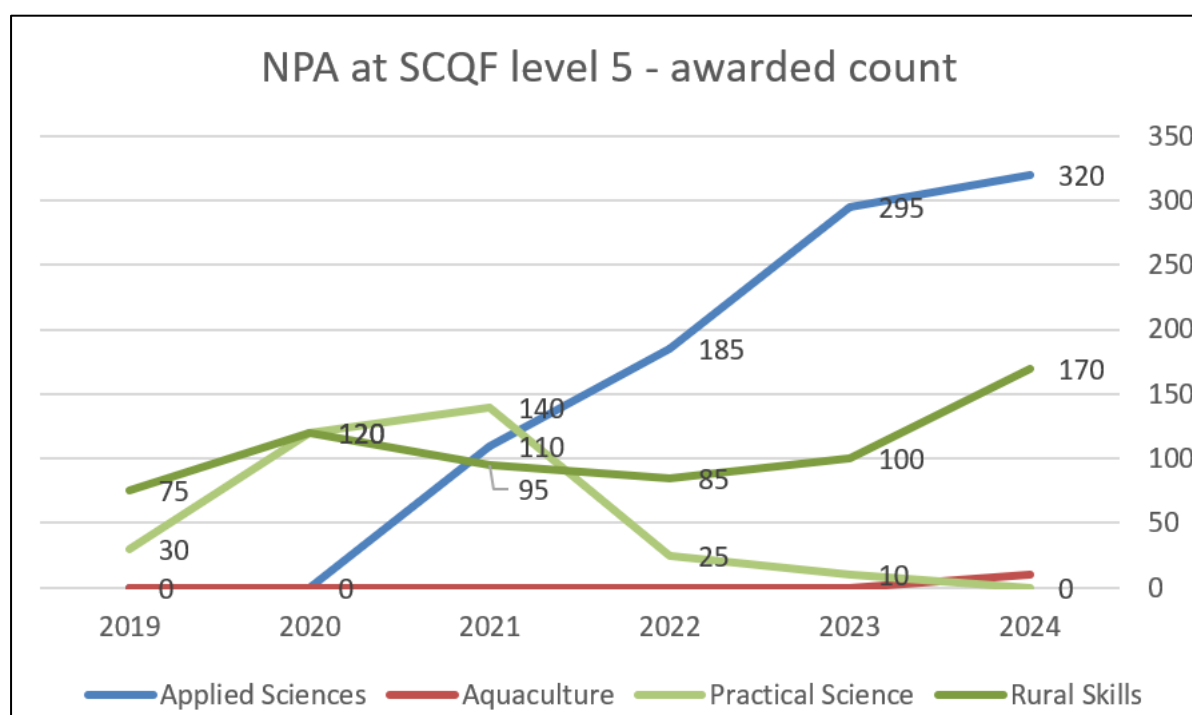
Data

Table 5 - NPA SCQF Level 4 awarded count (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
Aquaculture	Awarded Count	10	5	5	35	30	25
Climate Change and Sustainability	Awarded Count	N/A	N/A	N/A	N/A	100	180
Horticulture	Awarded Count	90	85	55	85	140	205
Science and Health	Awarded Count	20	45	70	100	180	195
Science and Technology	Awarded Count	25	55	100	70	100	80

At SCQF Level 4, the most popular NPA qualifications with relevance to the sciences are Horticulture, Science and Health, and Climate Change and Sustainability (respectively).

SCQF Level 5



Graph 6 - NPA qualifications (SCQF Level 5) - Awarded Count 2019-2024 (SQA)

Data

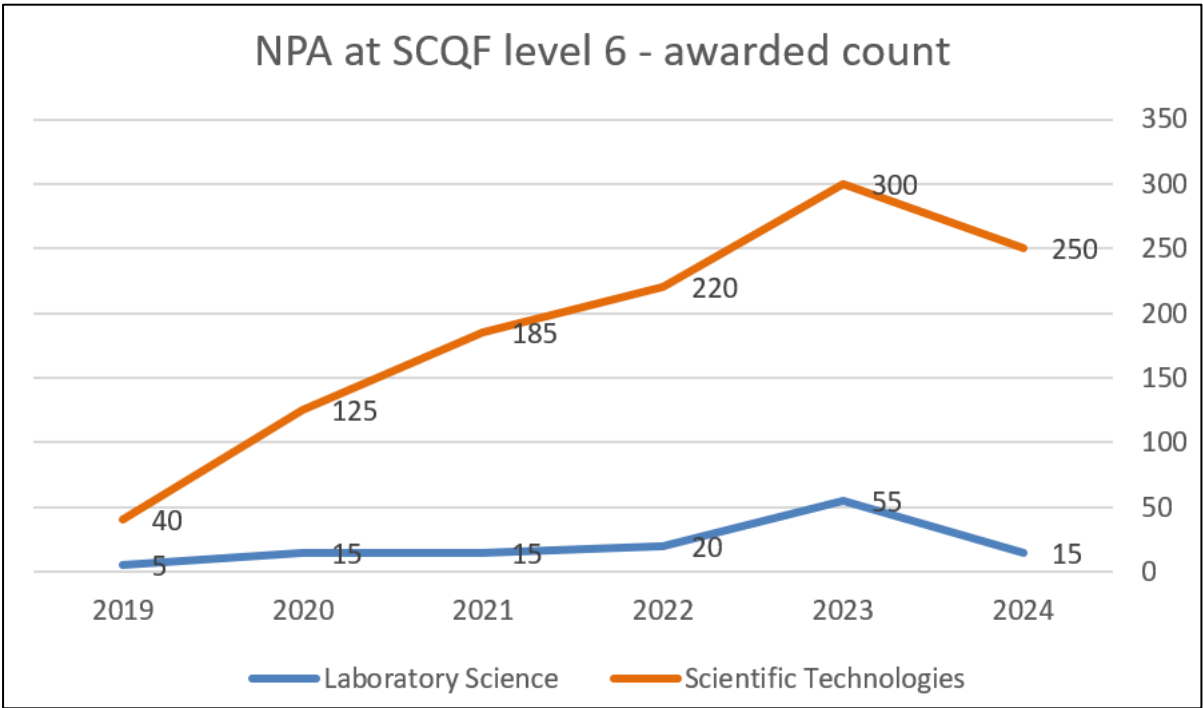
Table 6 - NPA SCQF Level 5 awarded count (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
Applied Sciences	Awarded count	N/A	0	110	185	295	320
Aquaculture	Awarded count	0	*	0	*	*	10
Practical Science	Awarded count	30	120	140	25	10	*
Rural Skills	Awarded count	75	120	95	85	100	170

* Data suppressed to protect against the risk of disclosure of personal information

Applied sciences is by far the most popular sciences-related NPA at SCCF Level 5.

SCQF Level 6



Graph 7 - NPA qualifications (SCQF Level 6) - Awarded Count 2019-2024 (SQA)

Data

Table 7 - NPA SCQF Level 6 awarded count (2019-2024)

Subject		2019	2020	2021	2022	2023	2024
Laboratory Science	Awarded count	5	15	15	20	55	15
Scientific Technologies	Awarded count	40	125	185	220	300	250

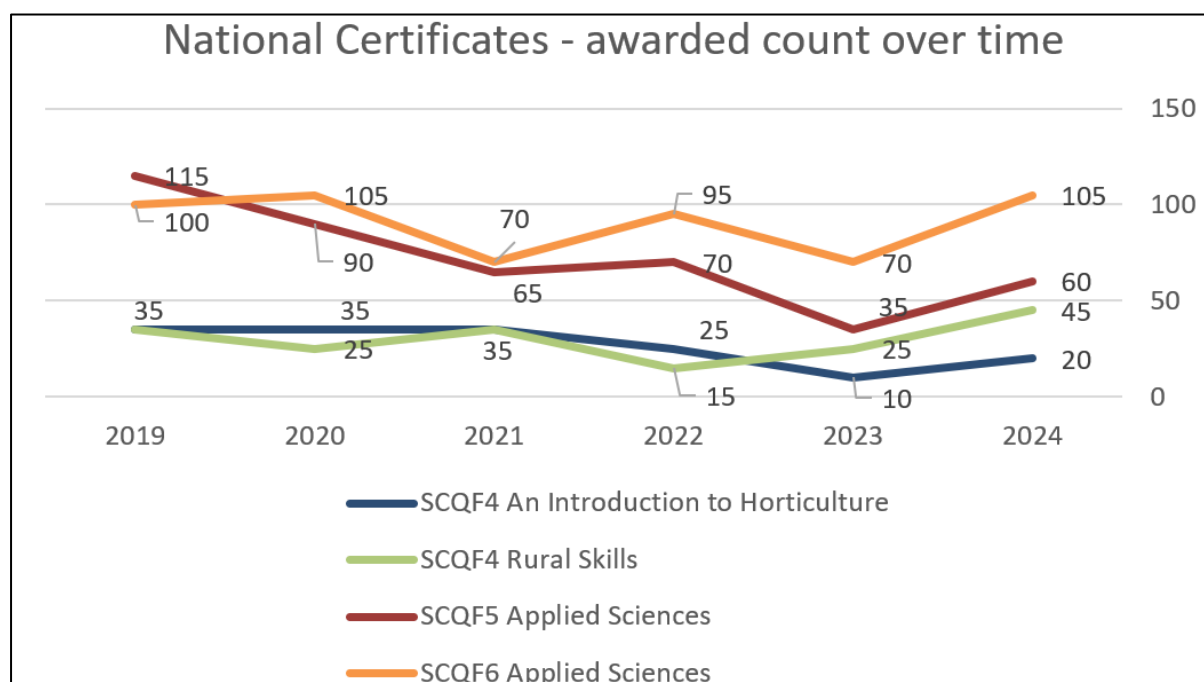
Scientific Technologies has the highest awarded count of the sciences-related NPAs at SCQF Level 6.

2.1.5 National Certificates

The most common sciences-related National Certificates include:

- SCQF Level 4: Introduction to Horticulture and Rural Skills
- SCQF Level 5 and 6: Applied Sciences

The following graph shows the awarded count over time for each of these qualifications. Please note, only awarded count is available for these courses and numbers of entries is not included.



Graph 8 - National certificate qualifications (SCQF Levels 4-6) - Awarded Count 2019-2024 (SQA)

Data

Table 8 - National Certificates SCQF Levels 4-6, 2019-2024

Subject		2019	2020	2021	2022	2023	2024
Introduction to Horticulture (SCQF level 4)	Awarded count	35	35	35	25	10	20
Rural Skills (SCQF level 4)	Awarded count	35	25	35	15	25	45
Applied Sciences (SCQF level 5)	Awarded count	115	90	65	70	35	60
Applied Sciences (SCQF level 6)	Awarded count	100	105	70	95	70	105

Given the low number of awarded counts in sciences-related National Certificates, the identification of trends or comparisons is best avoided.

2.1.6 Foundation Apprenticeships

Enrolment data for science-related Foundation Apprenticeships is included below (Skills Development Scotland, 2022). (Please note there are more STEM-related Foundation Apprenticeships. They have not been included here as the focus of this paper is on the sciences, rather than STEM).

- Food and Drink Technologies Foundation Apprenticeship (SCQF Level 6) enrolments fell by over 50% between 2019 and 2021. 2021 is the most up to date data available (2019 – 61; 2020- 42; 2021 – 29).
- Scientific Technologies Foundation Apprenticeship (SCQF Level 6) enrolments fell by 15% between 2019 and 2021. As above, 2021 is the most up to date data available (2019 – 108; 2020 – 97; 2021 – 92).

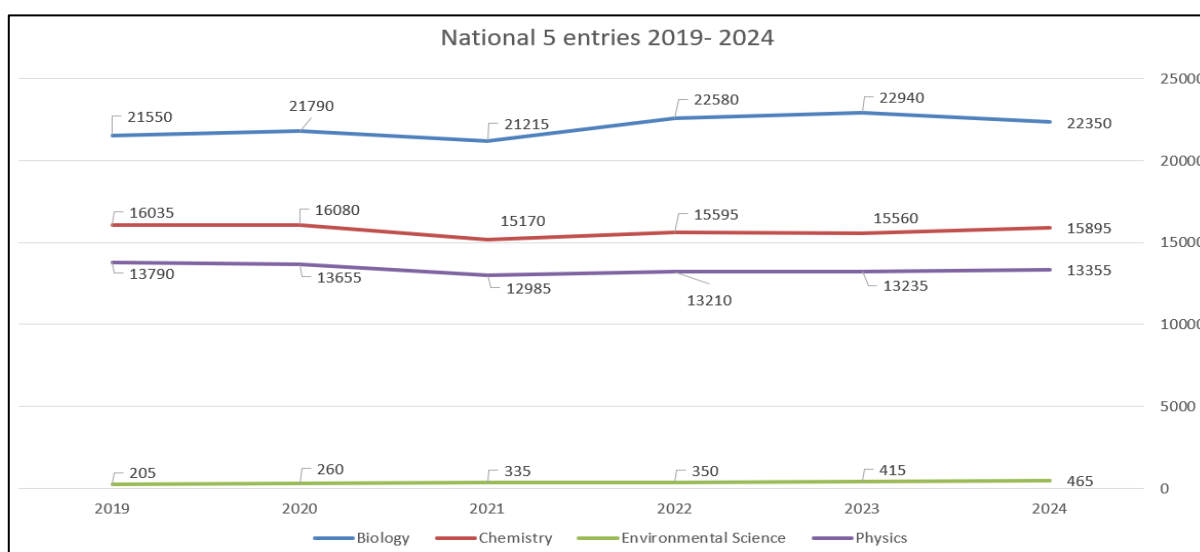
It is worth noting that this was at the height of COVID and delivery of practical subjects such as Foundation Apprenticeships, often delivered between school, colleges and employers, became exceptionally challenging.

2.1.7 SQA presentation data

Again, for the following graphs, please note that different scales have been used so as to best represent the data. All data is taken from the [SQA attainment statistics 2024](#). The percentage of passes included in data tables covers grades A-C. This is because grades A-C are considered a pass at the relevant SCQF Level (see [footnote 6](#)). Percentage passes have been included to make it easier to see the proportion of passes (rather than numbers of awarded count). Passes fluctuate in line with reasons already articulated around COVID-19 (such as the return to normal awarding model and generous grading).

National 5

The following graph and data show the entries for Biology, Chemistry, Environmental Sciences and Physics at National 5.



Graph 9 - National 5 qualifications - entries 2019-2024 (SQA)

Data

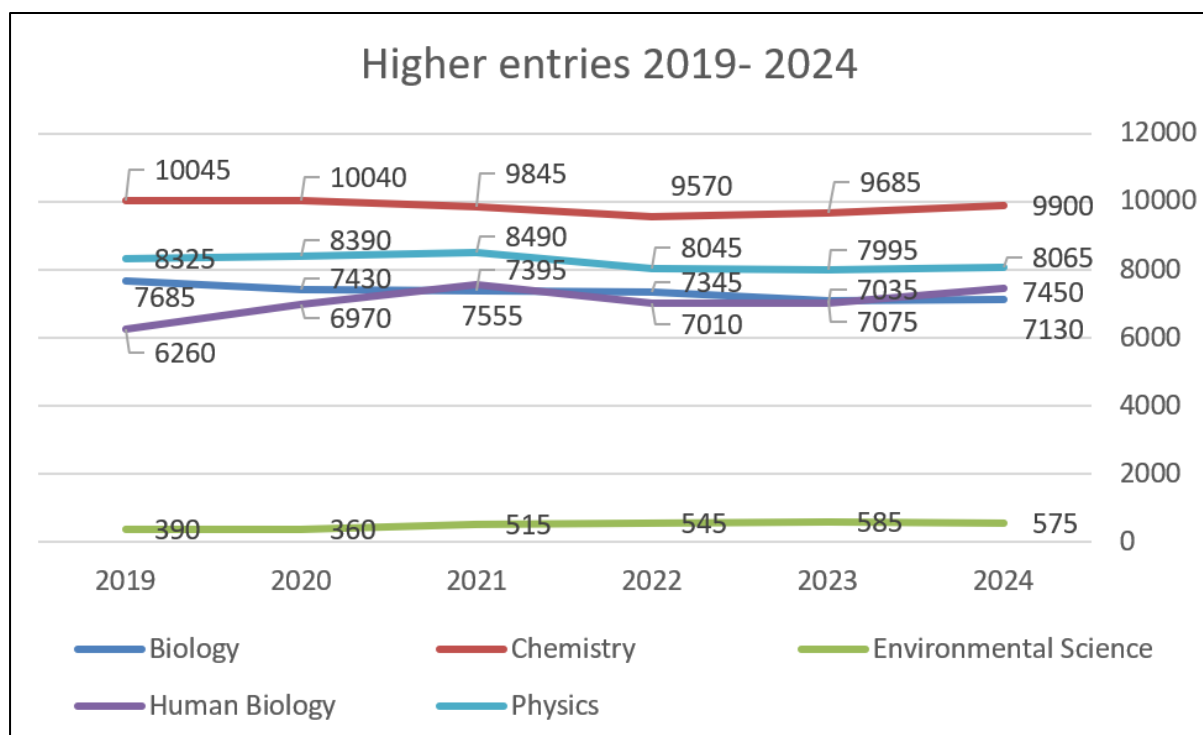
Table 9 - National 5 Entries and % A-C passes, 2019-2024

Subject		2019	2020	2021	2022	2023	2024
Biology	Entries	21,550	21,790	21,215	22,580	22,940	22,350
	% passes Grade A - C	70.6	83.4	75.8	72.3	73.0	64.6
Chemistry	Entries	16,035	16,080	15,170	15,595	15,560	15,895
	% passes Grade A - C	76.9	88.2	81.9	80.0	78.0	76.7
Environmental Science	Entries	205	260	335	350	415	465
	% passes Grade A - C	48.8	86.0	82.3	65.1	46.0	57.8
Physics	Entries	13,790	13,655	12,985	13,210	13,235	13,355
	% passes Grade A - C	74.6	86.0	81.3	74.2	71.0	73.9

Similar to Higher, the number of entries remains broadly steady across all the N5 sciences qualifications. Biology has the highest number of entries for National 5.

2.1.8 Higher sciences in 2024

The following graph and data show the entries for Biology, Human Biology, Chemistry, Environmental Science and Physics at Higher.



Graph 10 - Higher qualifications - Entries 2019-2024 (SQA)

Data

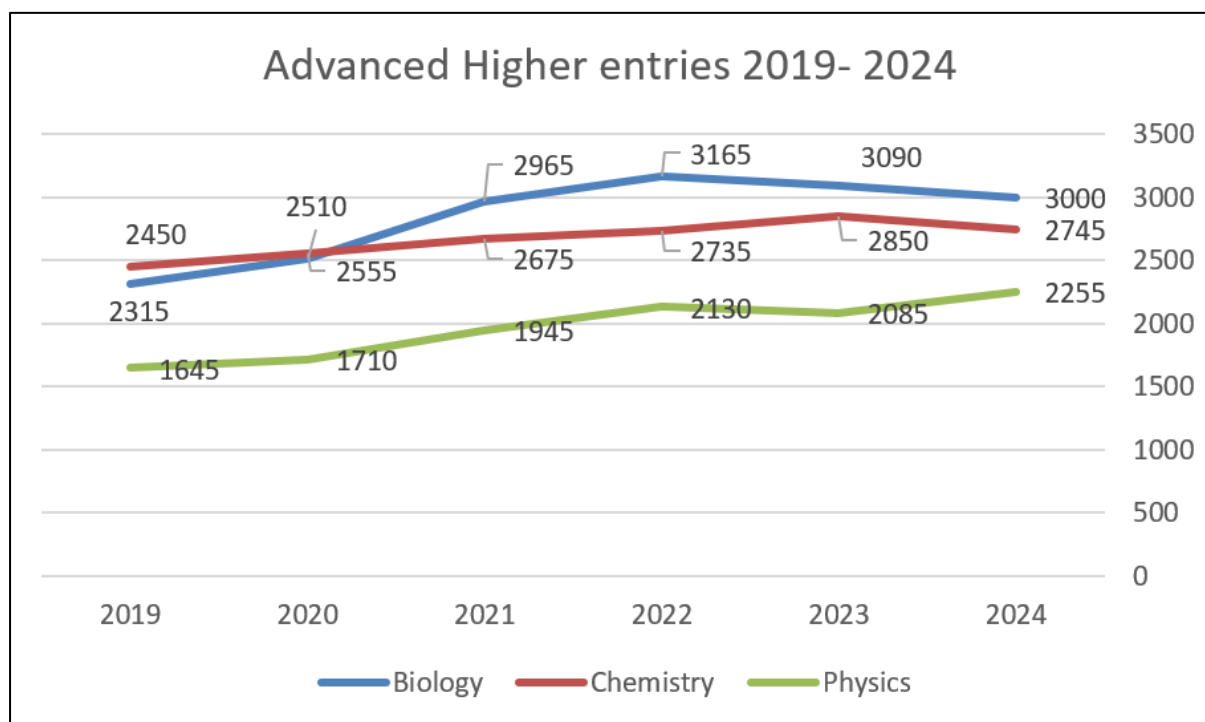
Table 10 - Higher Entries and % A-C passes, 2019-2024

Subject		2019	2020	2021	2022	2023	2024
Biology	Entries	7685	7430	7395	7345	7075	7130
	% passes Grade A- C	72.8	85.0	78.2	76.0	75.4	70.8
Chemistry	Entries	10,045	10,040	9845	9570	9685	9900
	% passes Grade A- C	75.8	88.3	81.5	78.7	77.8	74.4
Environmental Science	Entries	390	360	515	545	585	575
	% passes Grade A- C	68.4	89.4	80.4	72.2	59.5	54.0
Human Biology	Entries	6260	6970	7555	7010	7035	7450
	% passes Grade A- C	69.5	84.4	76.6	72.6	71.0	64.6
Physics	Entries	8325	8390	8490	8045	7995	8065
	% passes Grade A- C	75.0	86.6	80.8	78.0	77.3	75.7

Higher entries have been broadly stable in Chemistry, Biology and Physics between 2019 and 2024. Human Biology and Environmental Science have shown a slight upward trend over this same period. Between 2019 and 2024, Chemistry has the highest number of entries each year.

Advanced Higher

The following graph and data show the entries for Biology, Chemistry and Physics at Advanced Higher.



Graph 11 - Advanced Higher qualifications - Entries 2019-2024 (SQA)

Data

Table 11 - Advanced Higher entries and % A-C passes, 2019-2024

Subject		2019	2020	2021	2022	2023	2024
Biology	Entries	2315	2510	2965	3165	3090	3000
	% passes Grade A- C	74.2	89.2	84.1	75.8	74.5	67.0
Chemistry	Entries	2450	2555	2675	2735	2850	2745
	% passes Grade A- C	82.3	92.7	86.2	82.4	78.9	71.2
Physics	Entries	1645	1710	1945	2130	2085	2255
	% passes Grade A- C	78.8	93.2	88.1	81.3	79.4	72.9

There has been an overall increase in entries in all three sciences Advanced Highers between 2019 and 2024, with Physics increasing by 37%, Biology 29.6%, and Chemistry by 12%.

2.1.9 SQA course reports

This following provides an exploration of student performance in SQA sciences qualifications in 2024 and will cover general points which are common across all levels. Detail about performance in individual questions will not be covered here and can be found in the SQA course reports (linked below per subject area):

Biology (National 5, Higher, Higher Human, Advanced Higher)

The 2024 course reports for biology point to several positives. There was evidence of improvements in numeracy skills and candidates prepared well for the assignment at National 5 and Higher level. At Advanced Higher level, candidates performed strongly in extended-writing questions.

However, literacy skills, including understanding the stem of questions and using precise terminology, were highlighted as areas for improvement across all levels. Misuse of subject-specific terminology (e.g., "valid," "reliable," "accurate") was common.

Application of knowledge to new and unfamiliar contexts was identified as an area for improvement.

Across all levels, lack of familiarity with experimental work (e.g., apparatus, design, protocol evaluation) was a recurring issue. Drawing conclusions and analysing indirect measurements were challenging, especially when higher-order skills were required. Analysis, conclusion, and evaluation were identified as areas for improvement in assignments and projects across all levels. Poor analytical and comparative skills were noted for handling experimental data.

Chemistry (National 5, Higher, Advanced Higher)

There were some positives in relation to Chemistry in the 2024 course reports. For example, candidates at National 5 level demonstrated improvements in their performance in the open-ended questions. At Higher level, candidates generally performed well in numeracy calculations set in a chemical context.

However, candidates demonstrated difficulties in addressing questions related to practical work at all levels. This includes summarising experimental methods (National 5 and Higher), evaluating procedures (National 5 and Higher), and evaluating experimental methods (Advanced Higher).

Candidates at both National 5 and Higher levels find making comparisons between sources and evaluating procedures challenging.

Physics (National 5, Higher, Advanced Higher)

Positives were noted in the 2024 course reports for physics. At National 5 level candidates, in general, coped particularly well with questions requiring the selection of a relationship, followed by a calculation and final answer. At Advanced Higher, candidates were, in general, well prepared for the question paper, and showed a good

understanding of the majority of the concepts tested. As with National 5, candidates did well in completing questions assessing their ability to select and use relationships to determine values.

However, across all levels, issues with literacy were noted, including lack of precision in language and poor written English.

The answering of questions requiring explanation or justification, was a common challenge. Candidates across all levels struggled to evaluate experimental procedures effectively, particularly in assignments and projects. A lack of familiarity with experimental work and techniques was noted, affecting performance in assignments and question papers.

Environmental Science (National 5, Higher)

There were several positives highlighted in the 2024 course reports for Environmental Science. At National 5 level, more candidates attempted to answer the extended-response questions in section 3 of the paper than in previous years. Most candidates had a clear understanding of what was required for the assignments, particularly in terms of layout and organisation of their reports. At Higher level, the number of 'no responses' was noticeably lower than in previous years. Numeracy skills were also much improved, with most candidates achieving at least partial marks for calculations.

Across both levels, candidates struggled with aspects of the assignment task, including demonstrating understanding of the underlying science behind their experimental work, and evaluating experimental procedures. Their ability to make comparisons between data sources was often affected by poor choices in relation to secondary data sources.

In summary

Poor literacy skills were identified as an aspect for development across all National 5 to Advanced Higher sciences qualifications. This demonstrates the importance of disciplinary literacy as a consideration in the evolved sciences curriculum. Numeracy was also commonly highlighted as an area for improvement in terms of the handling of, and comparing of, data. This emphasises the importance of ensuring a strong alignment between the mathematics and sciences curriculum going forward. The course reports point to gaps in the knowledge and experiences of learners in relation to practical sciences, and associated skills, which is affecting attainment. The new curriculum should emphasise and support the practical nature of the sciences to address this.

Each of these common themes will need to be considered for a future sciences curriculum and its assessment methods.

2.2 Labour market information

2.2.1 Future looking labour market information

On a global level, the World Economic Forum (2025) [Future of Jobs Survey 2024](#) outlines the share of employers who consider various skills to be core skills in 2025 and share of employers expecting skills to increase in importance by 2030. Networks and cybersecurity as well as environmental stewardship are listed among the top 10 skills expected to significantly increase in use by 2030, yet are not currently considered core skills for most organisations.

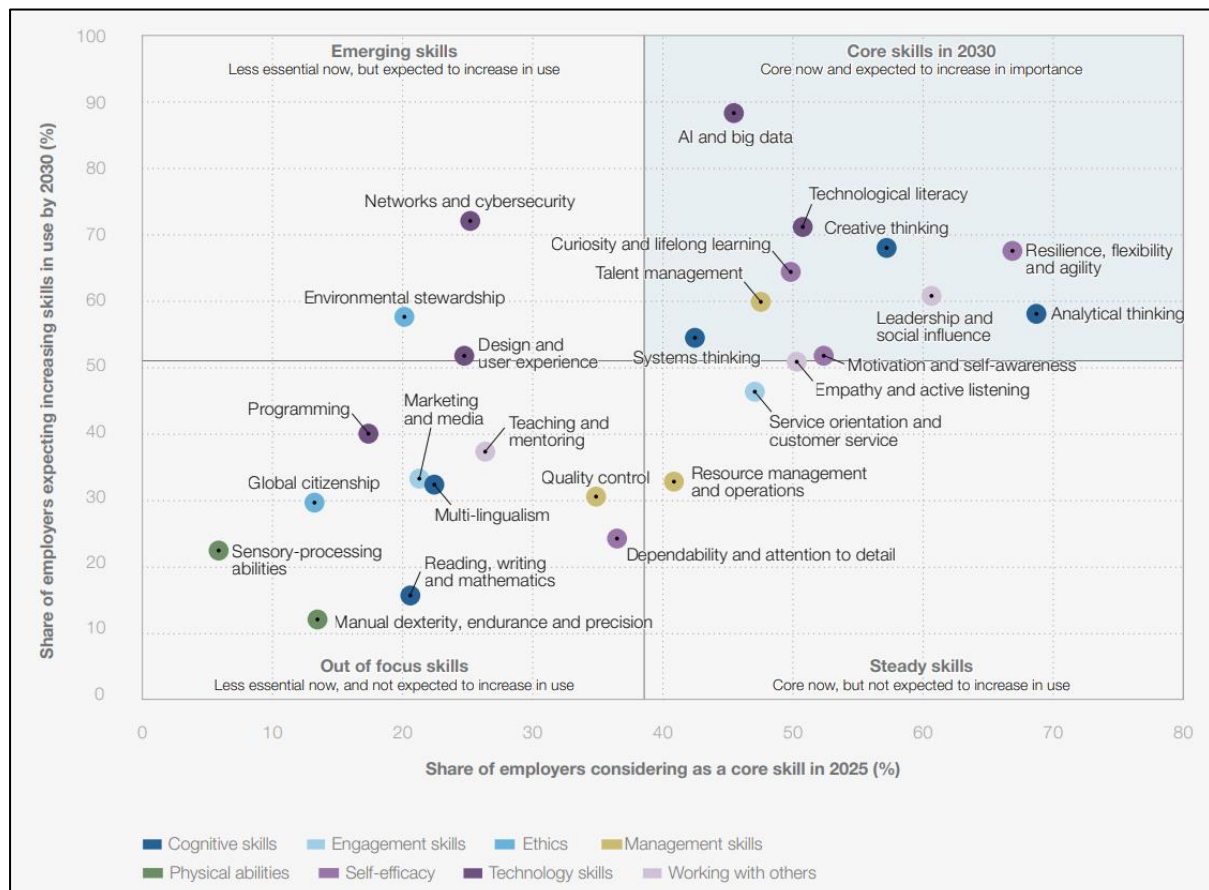


Figure 1 - Share of employers considering skills to be a core skill in 2025 and share of employers expecting skills to increase in importance by 2030 (WEF, 2025) (View on Tableau Public: [Future of jobs - core skills 30 | Tableau Public](#))

A recent Horizon Scanning Project: Future Trends for Scotland (Scottish Government, 2025) outlines three key trends for Scotland's labour market and skills:

- Scotland's working-age population is growing, however, ageing and ill-health create uncertainty for the future labour market.
- Automation and decarbonisation are expected to change the labour market, displacing and creating jobs.
- The focus on lifelong learning and skills will grow in future.

Coupled with this, Skills Development Scotland (SDS) provides detailed labour market information using a consistent evidence base to inform future investment in skills, built up from existing datasets and forecasts.

They work with key partners and stakeholders in the production of regional skills assessments to ensure an inclusive approach to their development, dissemination and utilisation. Regional skills assessments (RSAs) are published annually, covering all Regional Outcome Agreement areas, City and Growth Deal Regions and rural Scotland. The RSAs offer detailed information on regional labour markets across the country. The data included in these publications, including Oxford Economics forecast data, is the most up-to-date available at the time of writing.

The following graphs show labour market information access in November 2024 to show a 10-year forecast for Scotland as a whole. They were taken from the [SDS skills planning data matrix](#).

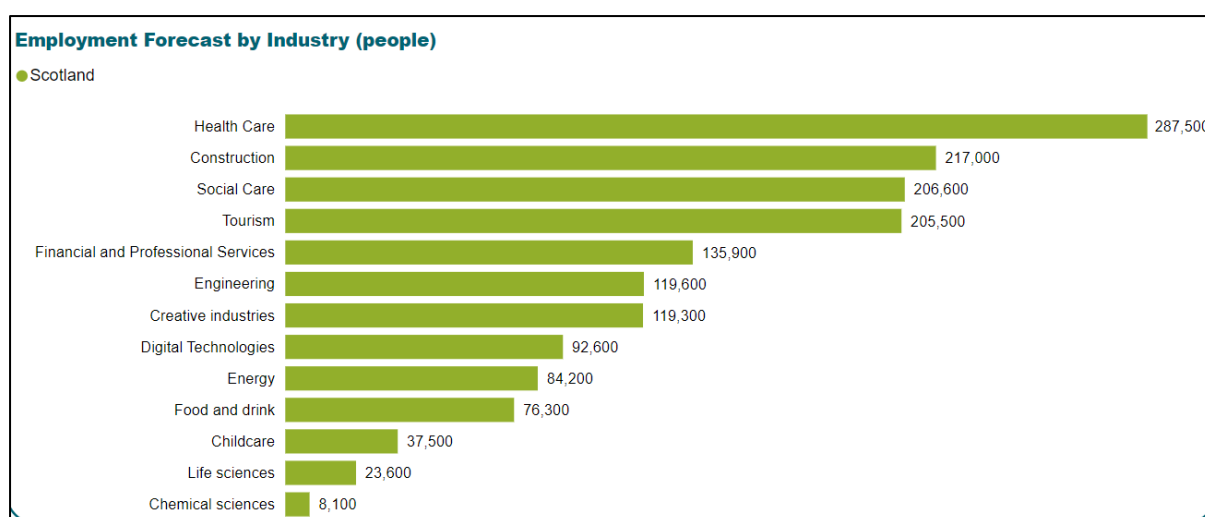


Figure 2 - Future employment forecast by industry for Scotland in 2034 (SDS, 2025a)

As can be seen in Figure 2; health care, construction and social care are predicted to be the highest employing industries. Health care and construction have particular implications for science as these areas require scientific skills, knowledge and understanding. Health care industry includes jobs such as clinical engineer, radiographer, optometrist, physiotherapist (Skills Development Scotland, n.d.) as well as innovation in areas such as digital healthcare, precision medicine and industrial biotechnology, all of which require scientific knowledge and understanding. Construction industry includes jobs such as engineers, architectural technologist, land surveyor, electrician and technicians (Skills Development Scotland, n.d.) as well as areas of innovation such as zero carbon-built environments, again requiring key scientific knowledge and skills to enter into these areas of work. There are other industries listed in figure 2 that are significant for the sciences including: engineering, digital technologies, energy, food and drink, life sciences and chemical sciences.

Although not explicitly mentioned in the SDS labour market information data, there are other economic sectors where science knowledge and skills play a critical role and where there are increasing workforce demands in the Scottish context. These include amongst others, the space industry (Space Scotland, 2021), advanced manufacturing

(Scottish Government, 2021a), nature and land-based industries (Scottish Government, 2023a) and the shift to the green economy (Scottish Government, 2024b).

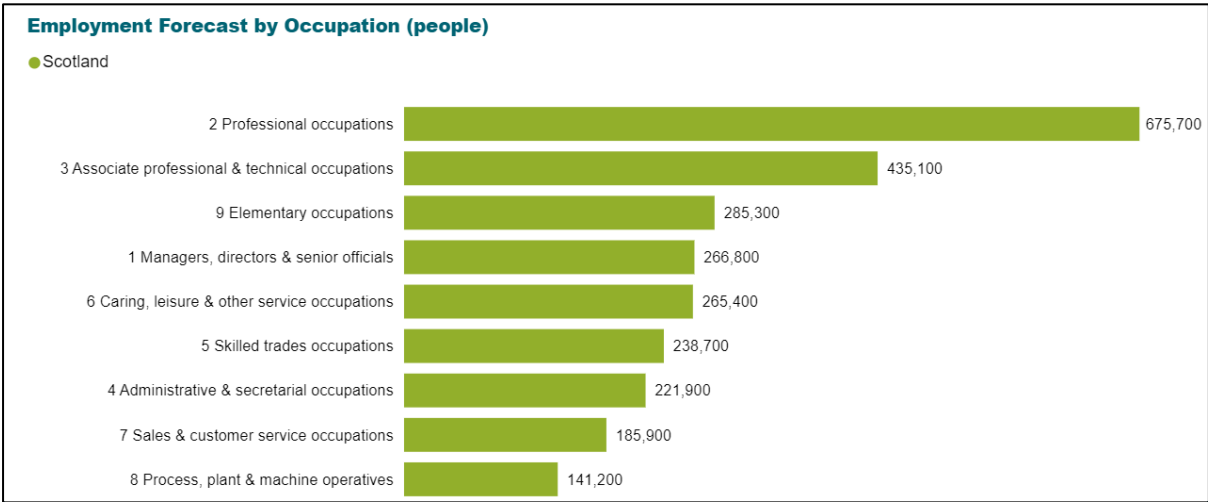


Figure 3 - Future employment forecast by occupation for Scotland in 2034 (SDS, 2025a)

Figure 3 shows employment forecast by occupation. This has implications for the range of pathways at different SCQF levels needed to allow learners to achieve the right level of qualifications for the jobs available. Science has a very diverse range of pathways available. However, uptake does not always match. This suggests further work may be required to raise awareness about pathways with schools, settings, learners and parents and families.

Total requirement by industry (2027-2034)³.

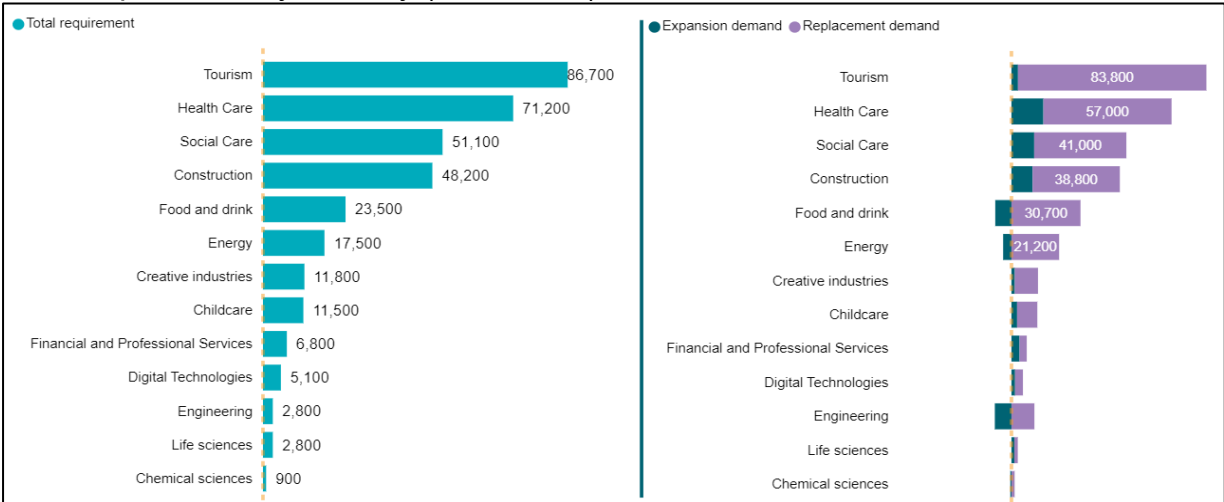


Figure 4 - Total requirement by industry for Scotland in 2027-2034 (SDS, 2025a)

³ Expansion demand refers to the net change in total employment by industry over the forecast period and thus the results can be positive or negative. For replacement demand, leaver rates by industry are calculated from the Labour Force Survey for Scotland. Replacement demand and expansion demand are summed to produce total requirement.

Despite health care being forecast to be the largest employing industry in 2034, the actual number of jobs needing to be filled is forecast to be greatest in tourism. The above graph on the right shows how much an industry is forecast to expand or reduce in requirement, as well as the likely replacement requirement (i.e. how many more people will be required due to people leaving the workforce). The graph on the left-hand side shows the total requirement. These numbers are different from the overall employment forecast as these graphs only show additional requirements and not those who will remain working in these industries. Health care, social care and construction show the greatest expansion demand, with food and drink, energy and engineering showing a negative expansion i.e. a reduction in requirements. Both of these will have implications for sciences education.

The recently published Young People's Career Ambitions report (YPCA) 2024 (SDS, 2025b) report collects views from senior phase learners and school leavers⁴ on a range of areas – ideal job and preferred industries being just one of these. One of the questions asked was: "Thinking about the future, what is your ideal job/career?". The following infographic shows a thematic analysis of their responses. The larger the circle, the more the job/career area was mentioned.

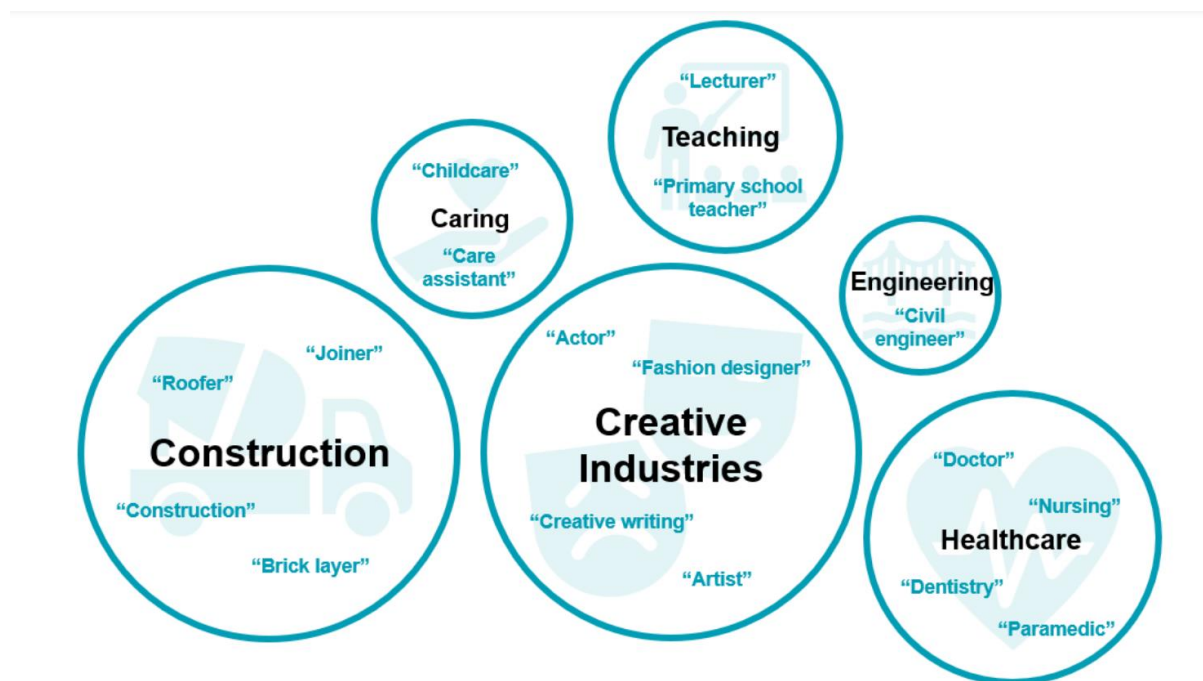


Figure 5 - Thematic analysis of young people's responses to the question: "Thinking about the future, what is your ideal job/career?" (n=1,629) taken from [Young People's Career Ambitions](#) (SDS 2025)

⁴ Data was collected from:

Pupil Voice Senior Phase (S4-S6). This research collected feedback from nearly 11,000 pupils in 2024, providing evaluation evidence on careers services and exploring broader themes related to senior phase students' career journeys.

Young People's Career Ambitions (1 year Post School). This research targets school leavers, focusing on their career journeys a year after leaving school. The 2024 study engaged almost 3,000 participants, exploring influences, motivations, and post school experiences.

Whilst there are some similarities to the labour market information, the largest area of interest to young people is creative industries, for which the requirement is less than half of that of health care (the top forecast industry in the labour market information). It can be said, therefore, that there is a mismatch in terms of what young people are interested in and what jobs will be available for them.

Interestingly, a [supporting infographic to the report](#) (SDS 2025c) shows that the preferred industry depends on a range of characteristics. For example, the infographic below shows the difference between males and females.

 Top Industries (Top 5, % selected)			
Female		Male	
Medicine and health	21%	Engineering	28%
Caring	17%	Construction	23%
Creative Industries	16%	Digital, computing, and IT	15%
Teaching / education	15%	Sport	12%
Media	11%	Media	10%

Figure 6 - Preferred industries by gender (SDS, 2025c)

There are also differences in terms of ethnicity. However, the report has low sample numbers for this and does not disaggregate by ethnicity (only offering the categories 'white' and 'minority ethnic').

 Top Industries (Top 5, % selected)			
Minority Ethnic		White	
Medicine and health	23%	Engineering	16%
Digital, computing, and IT	17%	Construction	14%
Media	16%	Creative Industries	13%
Engineering	13%	Medicine and health	12%
Creative Industries	12%	Teaching / education	12%

Figure 7 - Preferred industries by ethnicity (SDS, 2025c)

It also shows that there are marked differences in young people who are LGBT.

 Top Industries (Top 5, % selected)			
LGBT		Non-LGBT	
Creative Industries	29%	Engineering	18%
Media	20%	Construction	15%
Digital, computing, and IT	14%	Medicine and health	13%
Caring	14%	Teaching / education	11%
Medicine and health	14%	Sport	11%

Figure 8 - Preferred industries for young people who are LGBT vs non-LGBT (SDS, 2025c)

There is also a significant difference in industries selected for those from the most deprived areas (SIMD quintile 1) compared to those from the least deprived areas (SIMD quintile 5).

 Top Industries (Top 5, % selected)			
SIMD 1		SIMD 5	
Engineering	15%	Medicine and health	18%
Construction	14%	Engineering	16%
Caring	14%	Creative Industries	14%
Medicine and health	11%	Teaching / education	12%
Creative Industries	11%	Media	11%

Figure 9 - Preferred industries by SIMD (SDS, 2025c)

Care experienced children compared to non-care experienced children also show differences in their preferred industries.

 Top Industries (Top 5, % selected)			
CE		Not CE	
Construction	20%	Engineering	16%
Caring	12%	Creative Industries	14%
Hospitality	12%	Medicine and health	13%
Armed forces, policing or security	10%	Construction	12%
Engineering	10%	Teaching / education	11%

Figure 10 - Preferred industries by care experienced young people vs non-care-experienced (SDS, 2025c)

Lastly, learners with disabilities and those without also shows different preferences.

 Top Industries (Top 5, % selected)			
Disabled		Non-disabled	
Creative Industries	21%	Engineering	18%
Medicine and health	16%	Construction	15%
Caring	15%	Medicine and health	12%
Teaching / education	14%	Digital, computing, and IT	11%
Media	13%	Teaching / education	11%

Figure 11 - Preferred industries by young people with a disability vs young people without a disability (SDS, 2025c)

The report also shows there are small differences in who each of the above groups listed as key influencers on their career. The majority listed parents and carers as their top influencers (except care experienced learners who listed careers advisors). The next most commonly listed influencers were career advisors followed by other family members. Teachers also featured.

Finally, the factors influencing their chosen industry also vary by characteristic with most fluctuating between their 'interests and hobbies' and 'the need to earn money'. 'Qualifications achieved' also featured highly and 'education/training' to a lesser extent. Interestingly, 35% of young people cited social media as an influence with Tik Tok ranking the highest followed by Instagram and YouTube.

These differences highlight the importance of career education that works for, and is inclusive of, *all* learners, and that makes use of labour market information to help them

to make informed choices. The Curriculum Improvement Cycle should consider this when reviewing the content and structure of each curricular area and particularly in reference to skills.

2.2.2 Science and the talent pipeline

The following data relates to pathways, progression and the talent pipeline for science, taking into account the diversity of the sector. Again, the data is broadened to include STEM data as this is what is available. It is included to highlight there is a drop off in numbers of learners continuing with science both in school and post-school which may subsequently impact uptake in STEM-related employment. Statistics related to course attainment and pathways is outlined in section [2.1 Scottish Qualifications Authority \(SQA\) attainment and presentation data](#). As per section 2.1, it can be seen there has been a decline in the number of resulted entries in various National Qualifications. Reasons for this are also explored in section 2.1.

The proportion of pupils progressing from National 5 to Higher in 2023 to 2024 and 2022 to 2023 is outlined in Table 12. (SQAj, 2024).

National 5 Subject	Higher Subject	Proportion Progressing 2023 to 2024	Proportion Progressing 2022 to 2023
Biology	Biology	25%	25%
Biology	Human Biology	26%	24%
Chemistry	Chemistry	51%	51%
Environmental Science	Environmental Science	9%	16%
Physics	Physics	48%	48%

Table 12 - The proportion of pupils progressing from National 5 to Higher in 2023 to 2024 and 2022 to 2023

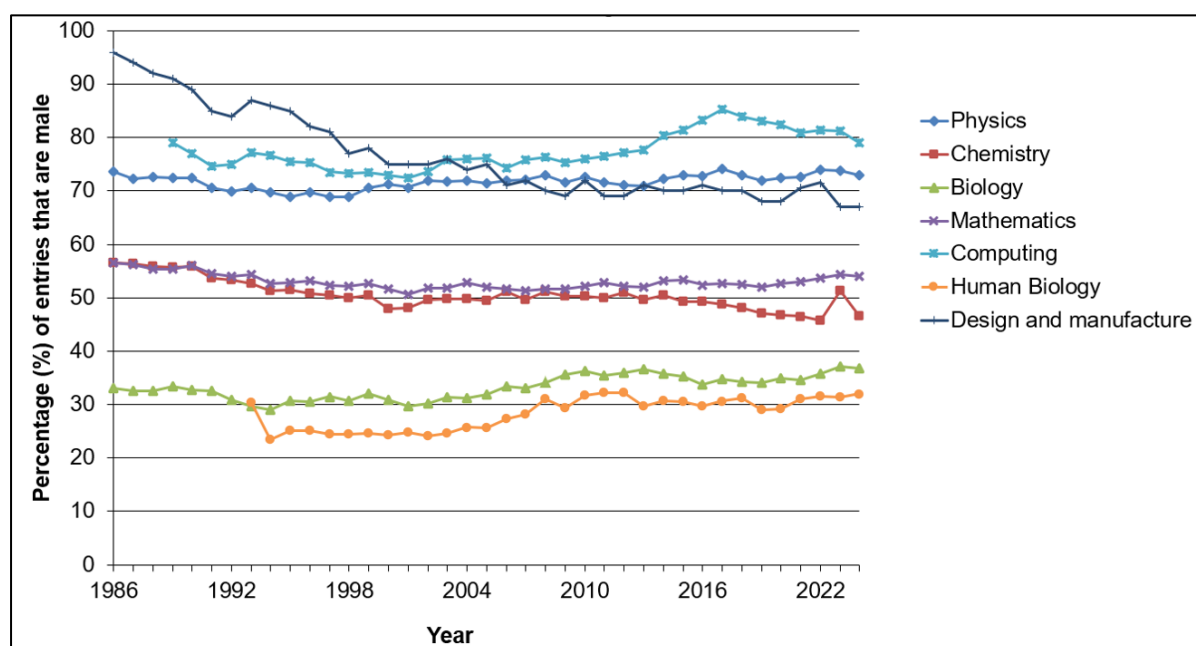
The table shows that there are fewer pupils taking Higher sciences compared to those with resulted entries at National 5. Interestingly, Advanced Higher Physics, Chemistry and Biology are amongst the top five Advanced Higher qualifications in terms of uptake, so retention is comparatively strong from Higher to Advanced Higher qualifications.

The progression in STEM post-school, despite small increases in uptake, show an overall inability to meet replacement demand. The proportion of STEM employers in Scotland with skills shortage vacancies was 6.4% in 2015 and 7.7% in 2017 (incidence). The 2017 figure was higher than the average incidence for all sectors in Scotland (6%), suggesting that STEM skills are particularly difficult to obtain for employers (Scottish Government, 2019a). Since the report, the skills gap has widened and is predicted to continue to do so particularly in industries such as energy as decommissioning and transition to cleaner energy takes place (Fraser of Allan Institute, 2024). STEM skills will be vital to support growth in sectors such as life and chemical sciences and renewable energy (key priorities in Scotland's National Strategy for Economic Transformation).

The ASPIRES research project (Archer et al., 2023) is a fourteen-year, mixed methods investigation of the factors shaping young people's trajectories into, through, and out

of STEM education. It highlights that in the English context, higher status 'Triple Science' GCSE routes are a form of science capital that is significantly associated with taking A level science and degree level science. In Scotland, science is not compulsory in S4 (the GCSE equivalent year group).

Despite many years of interventions, subject choice within STEM subjects is still highly gendered. See uptake of subjects at Higher level as an example (see graph) (SQA, 1986-2024).



Graph 12 - Uptake of STEM subjects at Higher from 1986 - 2024 (SQA, 1986 - 2024)

In the sciences, as can be seen from graph 12, biology is dominated by girls and physics by boys. Post-school intentions are also highly gendered. 14.4% of boys and 7.2 per cent of girls indicated they expected to work in the science and engineering profession. 6.4 per cent of boys and 19.1 per cent of girls indicated the health profession and 7.3 per cent of boys and 0.8 per cent of girls indicated the ICT profession (Scottish Government, 2019b).

The diversity of the current STEM workforce in Scotland similarly reflects this. Only 29 per cent of the STEM workforce in Scotland is female, compared to the workforce as a whole which is 49 per cent female (British Science Association, 2020). The proportion of the STEM workforce (in Scotland) from a minority ethnic background (5%) is higher than the proportion of the workforce from an ethnic minority background as a whole (4%). This differs too by industry.

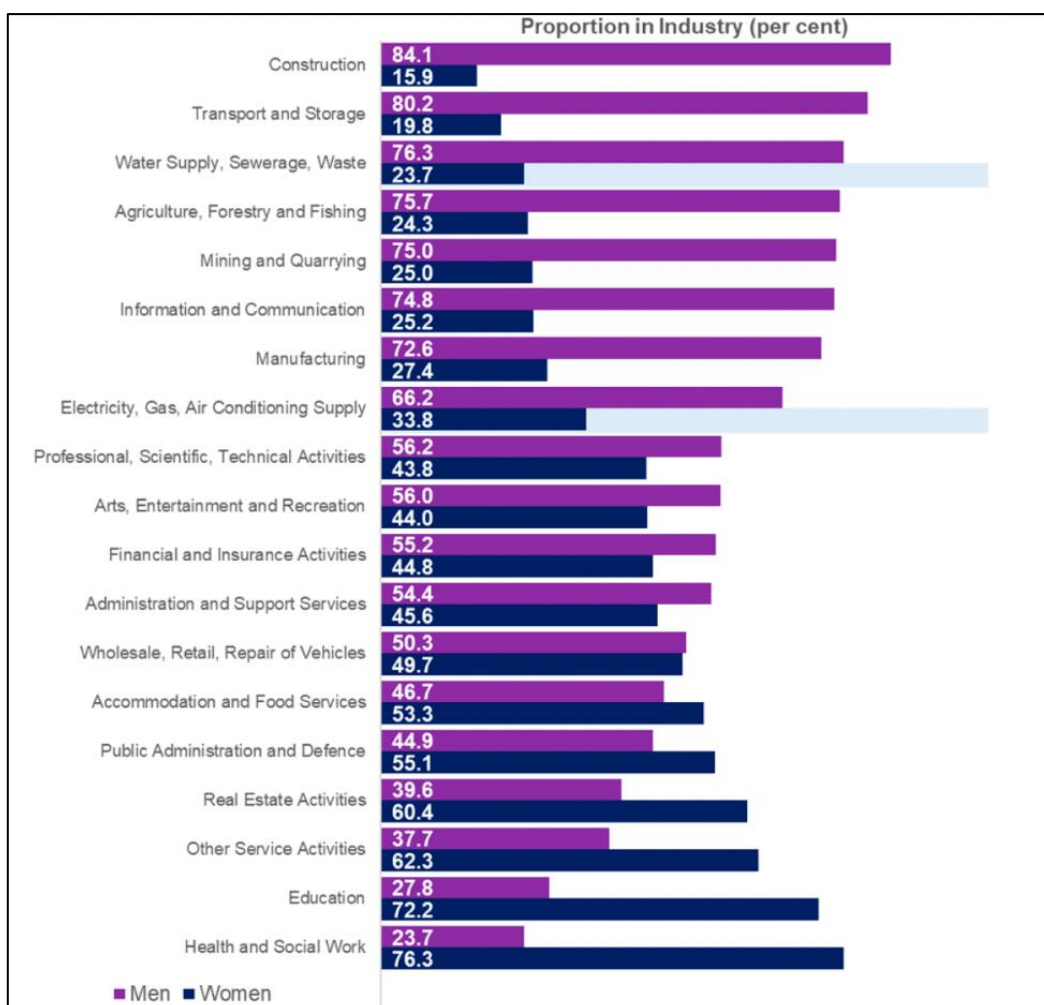


Figure 12 - Proportion of Employment in Sector aged 16 and over by sex, Scotland, April 2020-March 2021 (Scottish Government, 2021b)

Across the UK more broadly, and in relation to other characteristics:

- Disabled workers of all ethnicities are less likely to be STEM workers.
- Disabled people working in STEM are likely to be male, whereas a majority of non-STEM disabled workers are female.
- White women are less likely to be STEM workers than ethnic minority women.
- There is very little difference in the gender balance of the STEM workforce at younger ages.
- The science and maths workforce is more gender-balanced than other sectors but has a larger underrepresentation of disabled people than other STEM sectors.
- Women and minority ethnic employees are over-represented in the health workforce.
- The engineering workforce is predominantly comprised of White males.
- The STEM workforce is less diverse than the wider workforce (British Science Association, 2020).

The reasons for these disparities are often nuanced and complex and are explored more in [Section 6 – academic research](#).

2.3 National statistics

2.3.1 Achievement of Curriculum for Excellence Level (ACEL)

Achievement of Curriculum Levels (ACEL) data is published annually based on teacher judgement reporting on the percentage of school pupils in Primary 1 (P1), Primary 4 (P4), Primary 7 (P7) and Secondary 3 (S3) who have achieved the expected Curriculum for Excellence levels for Literacy and Numeracy relevant to their stage. Data is available on Curriculum for Excellence levels grouped by levels of deprivation, pupil characteristics, and by local authority. Data is also available for learners in Gaelic medium education, and those in special schools or units. It doesn't currently include data for science. There may be some correlation in performance in science and in literacy and numeracy given their importance to science. However, more analysis and research is needed to verify this.

3 International reports and comparative studies

This section looks at international reports which outline the importance of science to solving some of the world's complex problems. It then goes on to explore international comparative assessments (such as PISA), and what these tell us about Scotland compared to other participating countries.

3.1 International reports

3.1.1 Organisation for Economic Co-operation and Development (OECD)

OECD Draft Science Framework 2025

The OECD has produced a Draft Science Framework (OECD, 2023) on which the PISA 2025 assessments have been based. The PISA 2025 framework refines and extends the previous competencies by building on the PISA 2015 framework, and by drawing on the thinking of the expert group convened to develop this framework (membership of which can be found on page 3 of the [Framework document](#)).

The science framework describes three science competencies and a subset of three environmental science competencies. It also describes the three types of knowledge required by students for these competencies, the three main contexts in which students will face scientific challenges, and the aspects of science identity that are deemed important.

It explains that scientific understanding and science as the producer of reliable knowledge are particularly important in the 21st century when humanity faces an uncertain future as it enters the Anthropocene, an era in which human impact is significantly changing Earth's systems. A knowledge of science then matters at the individual, regional, and global levels as we seek to address these impacts.

The science competencies, contexts, knowledge and identity as proposed are outlined in Figure 13.

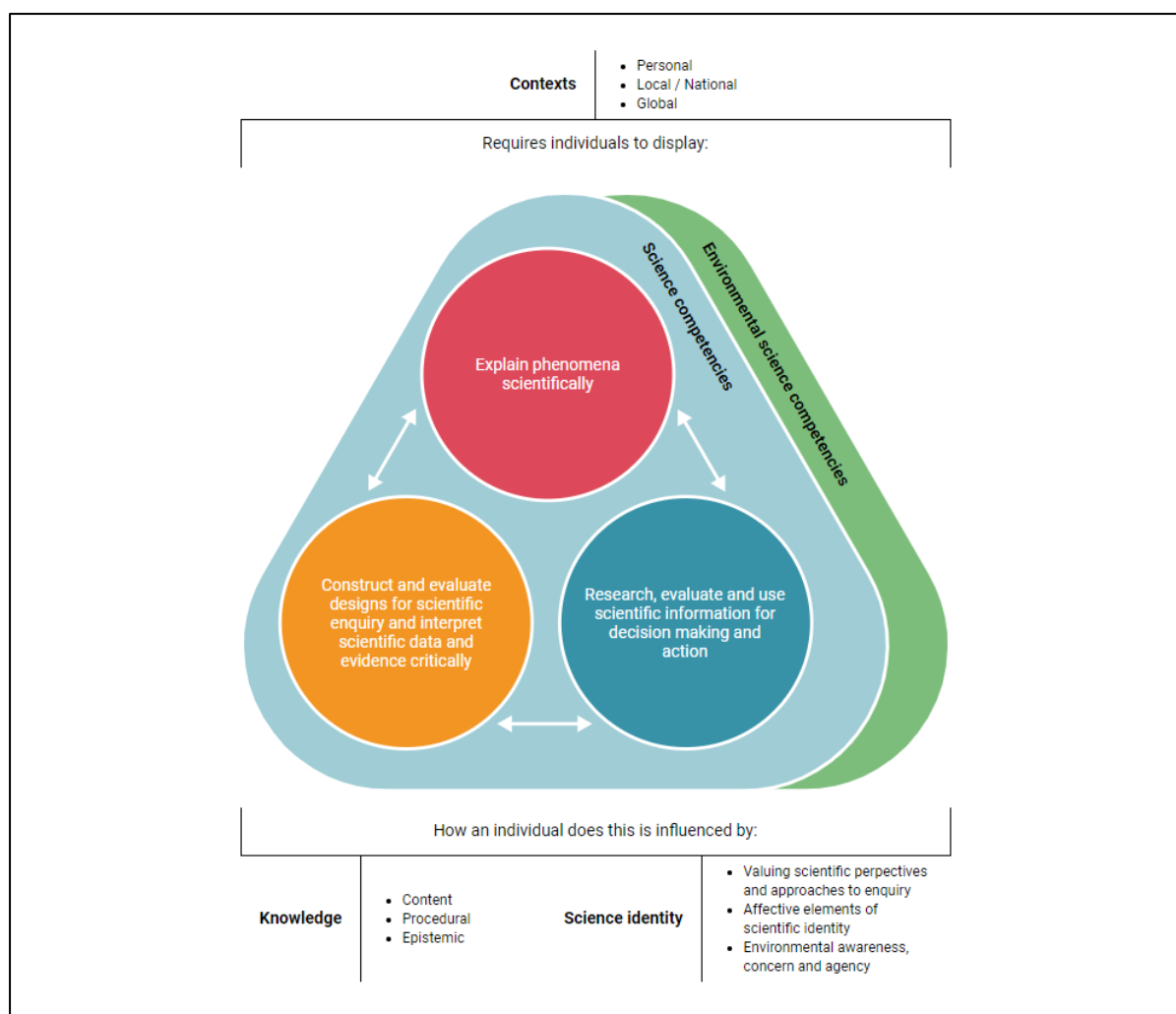


Figure 13 - Science competencies (OECD, 2023)

The three competencies can be expanded as follows:

1. *Explain phenomena scientifically*
- Recognise, construct, apply and evaluate explanations for a range of natural and technological phenomena.
2. *Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically*
- Appraise and evaluate ways of investigating questions scientifically and interpret and evaluate scientific data critically.
3. *Research, evaluate and use scientific information for decision making and action*
- Obtain scientific information on a specific global, local or personal science related issue and evaluate its credibility, potential flaws and the implications for personal and communal decisions.

Knowledge types can be expanded as:

Content knowledge: a knowledge of the facts, concepts, ideas and theories about the natural world that science has established.

Procedural knowledge: a knowledge of the practices and concepts on which empirical enquiry is based such as repeating measurements to minimise error and reduce uncertainty, the control of variables, and standard procedures for representing and communicating data.

Epistemic knowledge: includes an understanding of the function that questions, observations, theories, hypotheses, models, and arguments play in science, the values and issues that frame a question and drive scientific enquiry, a recognition of the variety of forms of scientific enquiry, and the role peer review and scientific consensus plays in establishing knowledge that can be trusted.

The paper goes into further detail about specific content, as well as the procedural and epistemic knowledge required, and can be found on pages 25-29 of the [PISA 2025 Science draft framework document](#).

Science identity is also included as a crucial measure of young peoples' sense of agency, attitudes, and values in relation to science and therefore their valuing of the knowledge and competencies of science as a way of thinking.

Science identity elements to be assessed are outlined below.

Science capital & epistemic beliefs

- Science capital (science-related knowledge, engagement with science, and social capital)
- Epistemic beliefs – general values of science and scientific enquiry

Science capital: attitudes and dispositions

- Science self-concept (sense of self in relation to science including future participation)
- Science self-efficacy
- Enjoyment of science
- Instrumental motivation

Environmental awareness, concern and agency

- Environmental awareness
- Environmental concern
- Environmental agency

The framework states that these areas were selected for measurement because they are important attributes of a scientifically educated individual.

Linked to the science competencies are environmental science competencies. These are shown in Figure 14.

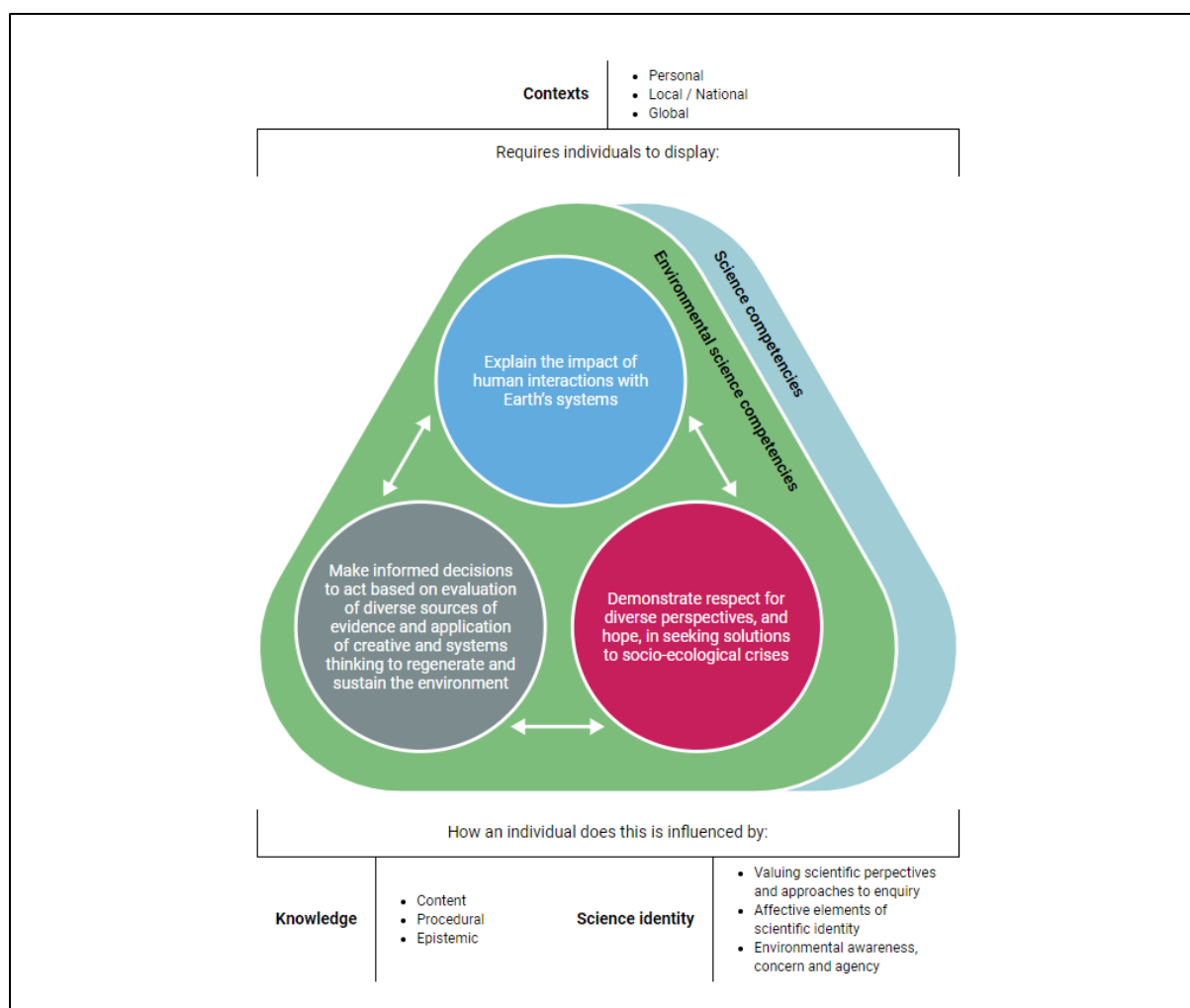


Figure 14 - Environmental Science competencies (OECD, 2023)

The framework explains the importance of the above by stating:

“A young person growing up into this anthropocentric world requires a range of competencies to address the issues of sustainability in an era of changing climate.”

Consideration of this framework will be important as it provides structure to the competencies, knowledge and contexts shown by research and practice to be significant for sciences education. This will help support thinking around the big ideas and conceptual knowledge for sciences.

3.1.2 United Nations Educational, Scientific and Cultural Organisation (UNESCO)

[Fostering Science for All: International Decade of Sciences for Sustainable Development](#) (UNESCO, 2024)

This paper sets out the importance of science as a powerful tool for addressing global challenges such as climate change, resource scarcity, and development inequality. It is framed around the fact that the world is not on track to meet the Sustainable Development Goals by 2030. It voices concern about public mistrust in science. It also states that transdisciplinary educational initiatives, medical breakthroughs, and

capacity-building efforts driven by science can reduce global inequalities and improve the quality of life in all the countries. Setting out the need for science to become more cognisant of these issues, it also links to an accompanying [strategic plan](#).

[Mathematics for action: supporting science-based decision-making](#) (UNESCO 2022)

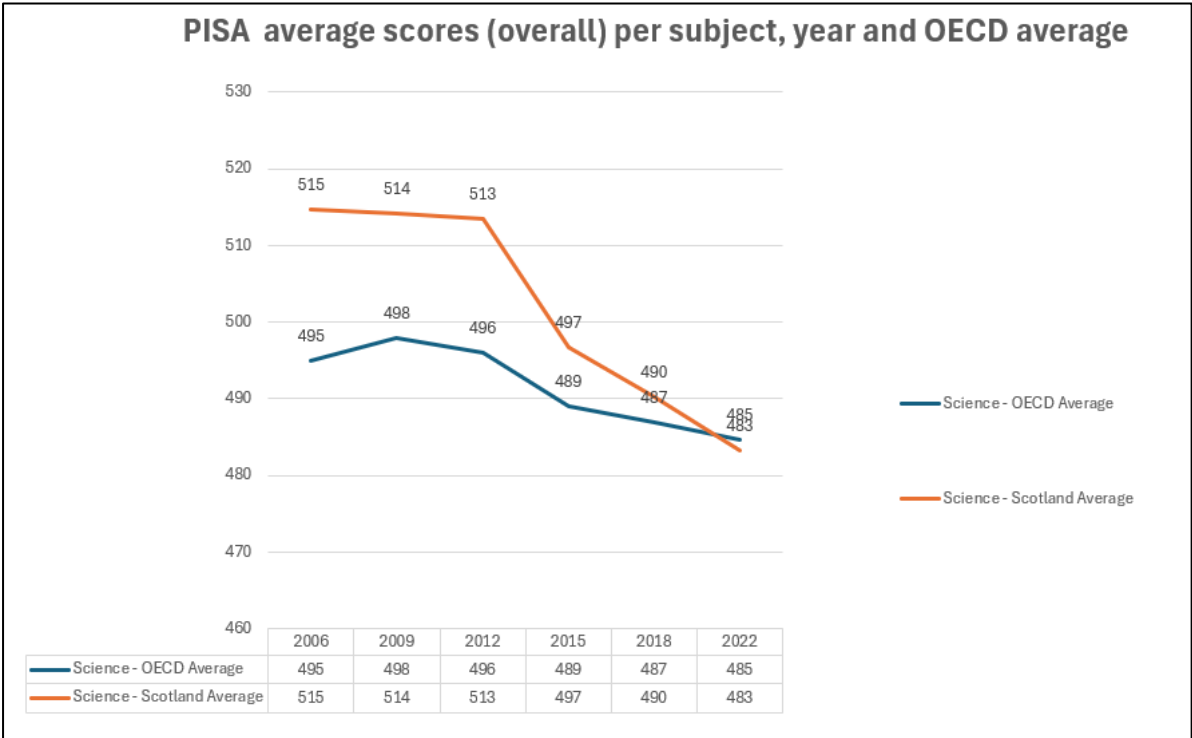
This toolkit provides insightful information for decision-makers and for all those who seek proofs to challenging questions and it presents new avenues for scientific research. It does so by outlining areas of complex and interconnected challenges using the UN Sustainable Development Goals as an organising framework. The toolkit shows the ways in which mathematical sciences can be useful in tackling these global problems. For example, Goal 3: Ensure healthy lives and promote well-being for all at all ages – looks at the novel ways mathematics has helped accelerate the design, testing, and monitoring of new vaccines, including the Sars-CoV-2 vaccines via an ‘enhancing vaccine design’ brief.

3.2 International comparative assessments

[Programme for International Student Assessment](#) (PISA) is the OECD's Programme for International Student Assessment. PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges. Science will be the main domain for 2025 PISA assessment. Approximately 3,500 learners from across 119 settings in Scotland will be taking part in the assessment in 2025.

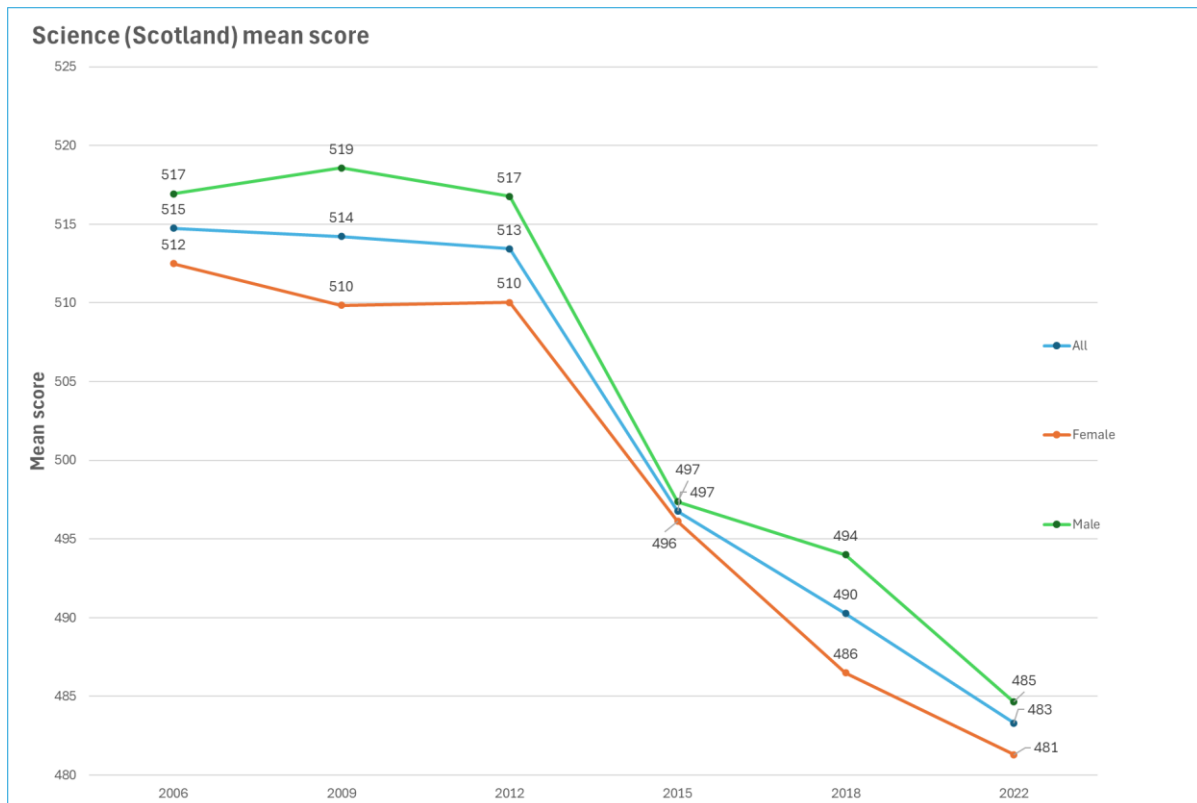
For the purposes of this paper, [Scotland's results](#) for science compared to the OECD average will be explored. Characteristics such as sex and whether or not students are immigrant, first- or second-generation immigrants will also be examined. Lastly, trends for the PISA sub-domains within science will be shown and trends identified.

Scotland’s overall average PISA score for science compared to OECD average (2006 – 2022).



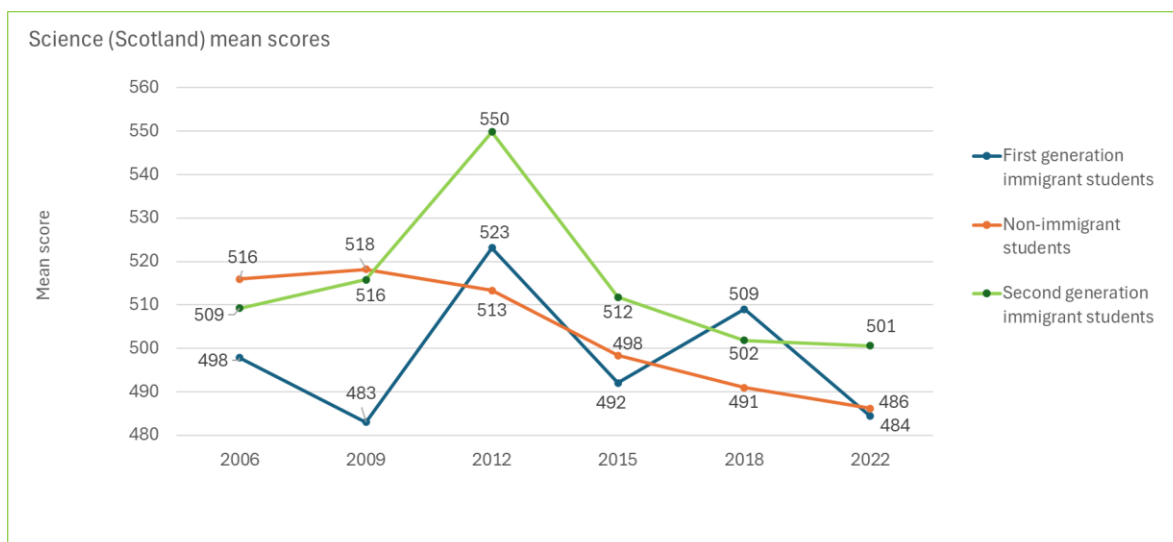
Graph 13 - Scotland's overall average PISA score for science compared to OECD average (OECD, 2006 - 2022)

As the graph shows, the average scores for both Scotland and the OECD in science show an overall decline from 2006 – 2022. Scotland's [mean score](#) in science in 2022 (483) was similar to the OECD average (485). Scotland’s mean score for science in 2022 was similar to the 2018 score (490), but lower than PISA cycles 2006 – 2015. There are a number of possible reasons for the overall declining trend. These may include, amongst other reasons, literacy proficiency in answering questions; the lack of familiarity in completing online assessments; and the disconnect between the topics in the PISA assessment and the content covered in the sciences curriculum in Scotland at this age. Further research and evidence is needed to verify the reasons for this trend.



Graph 14 - Trends in overall PISA scores for science (including by sex) (OECD, 2006 – 2022)

As can be seen from the graph, PISA scores for science show an overall decline over time. In 2006, the average score for students in Scotland was 515, decreasing to 483 in 2022. The trend is similar for both boys and girls.



Graph 15 - Trends in PISA scores for science by immigrant characteristics (OECD, 2006 – 2022)

As can be seen from Graph 15, PISA scores for non-immigrant students have shown a gradual decline. The score for first-generation immigrant students⁵ peaked in 2012, and overall, the science score for 2022 is broadly similar to that of 2006. For second-generation immigrant students, despite a peak in 2012, the overall trend is a decline in PISA scores for science.

In the PISA 2015 assessments for science, the following sub-domains were assessed:

- evaluate and design scientific inquiry
- explain phenomena scientifically
- interpret data and evidence scientifically
- content knowledge
- procedural and epistemic knowledge
- Earth and space
- living systems
- physical systems

Table 13 compares Scotland's scores for each of these sub-domains to the OECD average beginning with overall scores. Where the cell is coloured red it shows a decrease in performance, where it is green, it shows an increase in performance. The table is also broken down by gender.

⁵ The OECD define second generation immigrants as students where one or both parents were born in another country (i.e. not in the UK). First generation immigrants are where the student was born in another country (i.e. not in the UK). Non-immigrants are where the student and both parents were born in the UK.

Max of Average		Gender ▼		
Year and sub-domain		All	Female	Male
2015				
1. Overall				
	OECD Average	489	487	491
	Scotland Average	497	496	497
2. Evaluate and design scientific inquiry				
	OECD Average	488	491	486
	Scotland Average	498	503	494
3. Explain phenomena scientifically				
	OECD Average	489	482	495
	Scotland Average	498	494	502
4. Interpret data and evidence scientifically				
	OECD Average	489	489	488
	Scotland Average	493	495	492
5. Content knowledge				
	OECD Average	489	483	495
	Scotland Average	496	492	500
6. Procedural and epistemic knowledge,				
	OECD Average	489	490	487
	Scotland Average	496	499	493
7. Earth and space				
	OECD Average	489	487	491
	Scotland Average	494	492	496
8. Living systems				
	OECD Average	488	488	488
	Scotland Average	497	498	495
9. Physical systems				
	OECD Average	489	484	493
	Scotland Average	499	497	501

Table 13 - Scotland's scores for each of the science sub-domains in the PISA assessment, compared to the OECD average

This shows that in each sub-domain, Scotland's students have higher scores than the OECD average, despite an overall decline in PISA scores for science. There are subtle differences in performance by sex. Boys outperform girls in some sub-categories (explain phenomena scientifically, content knowledge, Earth and space, physical systems). Girls outperform boys in others (evaluate and design scientific inquiry, interpret data and evidence scientifically, procedural and epistemic knowledge, living systems).

The differences in content knowledge around living systems, earth and space and physical systems are unsurprising given the differences in uptake of biology (more girls tend to take) and physics (more boys tend to take).

[Trends in International Mathematics and Science Study \(TIMSS\)](#) 2019 results show the top performing country in science at both grade 4 (Scottish equivalent = P5) and

grade 8 (Scottish equivalent = S2) is Singapore. The study takes place every four years, the latest being in 2023. Scotland is not currently part of the TIMSS study (it left after the [2007 study](#)). However, Scotland has taken the decision to rejoin at the next TIMSS study in 2027.

4 Education Scotland evidence

This section examines evidence written or co-created by Education Scotland. It begins by outlining inspection data and thematics relevant to sciences and goes on to summarise data and reports evaluating STEM education in Scotland. STEM is referenced in part because a large body of evidence exists for STEM. It is important to acknowledge that in both early learning and childcare and primary education, science is often taught through STEM contexts.

4.1 His Majesty's Inspectorate of Education (HMIE) evidence and reports

Firstly, HMIE thematic reviews relevant to the sciences Curriculum Improvement Cycle will be summarised and key points highlighted. Secondly, a summary of inspection data that makes reference to science practice in primary and secondary schools will be included. This is a collation of the HMIE reports from visits to establishments between January 2019 and February 2024 (for secondary) and January 2018 – July 2024 for primary (with most of these reports coming from 2024). A larger timeframe was chosen for sciences as many inspection reports do not explicitly refer to science or STEM curriculum practice, nor do they commonly provide ratings for QI 2.2 (Curriculum) and QI 2.3 (Learning, teaching and assessment). Therefore, evidence is limited.

This summary does not include reports on settings that required a return inspection visit during this period. Care Inspectorate reports have not been included at this stage due to the ongoing development of a new joint inspection programme. This plan introduces a refreshed approach to multi-agency scrutiny and improvement support, which is still in progress. Once the updated framework and findings are fully implemented and published, they will provide a more comprehensive basis for inclusion in future curriculum evidence papers.

Enhancing the quality of mathematics education in Scotland (Education Scotland 2024a)

The report highlights the strengths and areas for development in mathematics and education, emphasising the value of nurturing relationships, especially in early learning and primary settings, to build learners' confidence and engagement. It calls for more focus on real-life applications – such as budgeting, cooking, and problem-solving – to boost relevance and motivation, noting that these approaches decline in secondary school. Assessment needs refinement, and greater use of technology can enhance learning and support needs.

Mathematical language was also highlighted as an area for improvement, and it was suggested that informal mathematical language should be avoided in primary schools. In secondary, it was noted that lessons were dominated by teacher talk and consideration should be given as to how to increase learners' communication and language skills in mathematics. Similar could be considered for the sciences. This has implications for sciences curriculum improvement as the sciences offer a natural real-life application of mathematical concepts. A key consideration for the

sciences improvement cycle will be how the sciences and maths curriculum can be better integrated to provide children and young people with engaging lesson content, applications in new and real-life contexts. Scientific language development and communication skills will also be key to this.

Summary of themes in inspection reports that explicitly mention science, STEM or outdoor learning (Education Scotland, n.d.-a):

In secondary schools' inspection reports the following elements of practice were highlighted for STEM / science:

- P7 transition activities where the secondary settings provided a programme of science learning for primary learners
- professional learning led by SSERC with primary cluster settings
- interdisciplinary STEM integration through S2 global-citizenship periods and dedicated periods of STEM for S1/S2 learners
- interdisciplinary learning (IDL) STEM challenge days / weeks
- pupil leadership opportunities via SSERC's Young STEM Leaders Programme
- attending 'girls into STEM and science events
- careers education with DYW/SDS, partners such as the Engineering Development Trust
- community partnerships to facilitate local projects (for example conservation projects)
- outdoor learning for specific learner groups
- in one setting, staff collaborate to ensure pupil voice influences the science curriculum leading to contextualised learning and greater pupil engagement
- systematic monitoring and tracking was also a theme

In primary schools, the following practice was highlighted for STEM/science:

- STEM/ science and outdoor learning were often provided together due to outdoor learning allowing the development of investigation and problem-solving skills – some settings were advised to further develop their outdoor learning provision.
- A number of clubs such as coding clubs, STEM clubs, Eco-Schools clubs and digital clubs were on offer for learners.
- STEM challenge days or weeks feature highly, often in partnership with local businesses, STEM providers, STEM ambassadors, families and the community. Some of these are real world STEM challenges situated in the local community, and included visits. Some offer opportunities for intergenerational working.
- Some settings have more regular partnership opportunities built-in and partners are involved in discussions about the scope and nature of the curriculum.

- Many settings have undertaken professional learning in STEM and confidence has increased as a result.
- Many settings have leadership roles associated with STEM provision.
- A number of settings have used professional learning and leadership roles to develop coherent and progressive science pathways from P1 to P7.
- Pupil Equity Funding (PEF) has been used for leadership roles focused on curriculum development but also family engagement.
- Some settings explore equalities issues relating to STEM / science.
- A few settings have dedicated STEM classrooms that are well resourced, allowing children to develop key scientific skills such as hypothesising, developing fair tests and drawing conclusions.
- Many settings have pupil leadership opportunities in STEM or science such as 'science champions', STEM ambassadors, Young STEM Leaders.
- One setting uses vertical groupings for masterclasses on STEM enabling children to use and develop meta skills.
- Play pedagogy is a common pedagogy for STEM and outdoor learning in primary schools, particularly at early level allowing the developing of curiosity and creativity.
- Some schools are using pupil feedback to shape learning activities based on their interests.
- In a setting that uses the Montessori approach, learners experience rich individualised learning about science, history, geography, culture, mathematics and language.

In summary, secondary school inspection reports were more limited in the commentary around sciences curriculum provision and focused on more whole school initiatives that included science such as STEM periods, STEM challenges and transition events/programmes. Pupil leadership opportunities were common for both, but outdoor learning was much less of a feature in secondary than it was in primary. In the primary inspection reports, STEM as a vehicle for delivering science was much more common as well as play pedagogy. STEM challenges were also a feature in primary settings. Inspection reports commented on planned progression and pathways for science more commonly in primary schools, linking this with the importance of professional learning around STEM for both practitioner confidence and leadership roles. Also mentioned was the resourcing of STEM through dedicated spaces and resources. Partnership, community and family working was also more common in primary inspection reports.

4.2 Education Scotland reports and evidence

The following Education Scotland reports and evidence focus mostly on STEM. This is largely due to the resource and funding that was made available to Education Scotland between 2017 and 2024 to support Scotland's STEM Education and Training Strategy. The data on STEM, however, is relevant and applicable to sciences too. Please also note that Ekosgen was appointed by Education Scotland to independently review the STEM Grants Programme and aspects of the STEM Strategy.

4.2.1 Structural barriers to STEM engagement

[The Structural Barriers to STEM Engagement – Final Report for Education Scotland \(Ekosgen, 2022\)](#)

The report identifies several main structural barriers to STEM engagement, including:

1. *Limited resources* – schools often have a mixed level of commitment to STEM, which is influenced by the resources available within local authorities. Many schools report a lack of teaching resources and the ability to invest in them, which hampers effective STEM education delivery.
2. *Recruitment and retention of STEM teachers* – there are significant challenges in recruiting STEM teachers, and high staff turnover affects the continuity and quality of STEM learning. Ensuring that teachers possess the necessary STEM skills and capabilities is also a concern.
3. *Curriculum delivery and assessment demands* – the current curriculum requirements restrict the ability to develop and deliver innovative STEM content. This leads to a siloed approach to teaching, making it difficult to integrate STEM across different subjects.
4. *Timetabling constraints* – rigid timetabling within schools limits students' choices regarding STEM subjects, which can discourage engagement. There is a demand for increased flexibility in timetabling to allow more learners to pursue STEM subjects of interest.
5. *In-school influencers* – the impact of guidance staff, STEM ambassadors, and young STEM leaders is often insufficient. Strengthening their roles is crucial to positively influence students' perceptions and confidence in pursuing STEM education.
6. *Transition challenges* – there are difficulties in ensuring smooth transitions from primary to secondary education, particularly in maintaining engagement in STEM subjects during the S1-S3 phase. This is a critical period where students' confidence and perceptions of STEM can significantly affect their future subject choices.

These barriers highlight the need for strategic interventions to enhance STEM engagement and education in schools. The report goes on to make several key recommendations for addressing the challenges and structural barriers to STEM engagement.

Recommendations:

1. *Explicit remit for STEM in improvement plans* – Regional Improvement Collaboratives (RICs) should have a clear mandate to include STEM actions in their improvement plans, ensuring that STEM is aligned with existing educational priorities such as literacy and numeracy.
2. *Innovative qualification pathways* – consideration should be given to introducing new and innovative qualification pathways that can widen access to STEM learning and careers for all learners, regardless of their backgrounds or current levels.
3. *Increase visibility of STEM* – efforts should be made to enhance the visibility of STEM to learners, particularly during the broad general education (BGE) phase. This could involve using real-world STEM examples and adopting flexible teaching approaches, such as interdisciplinary learning (IDL) and project-based learning.
4. *Support for IDL and joint lessons* – Education Scotland and partners should explore ways to support schools in planning and delivering IDL and collaborative lessons, as well as creating more flexible and effective teaching spaces within schools.
5. *Strategic approach to STEM teacher recruitment* – the Scottish Government and strategic partners should develop a cohesive strategy for recruiting STEM teachers to address the ongoing challenges in this area.
6. *Encourage collaboration between schools and colleges* – greater collaboration between schools and colleges should be facilitated to improve alignment and support for STEM education, enhancing pathways from school to further education.
7. *Simplify and join up the STEM education landscape* – there should be an exploration of how to simplify and join up STEM education landscape to benefit the overall learner experience, ensuring that all stakeholders are aligned in their efforts to promote STEM.
8. *Improved links between schools and business* – 59% of parents want more opportunity for their children to work with businesses through their learning, whilst 52% would like their children to receive more information on STEM jobs through their learning. 47% of parents would like to see more work experience.

4.2.2 Factors in successful STEM engagement

[Factors in Successful STEM Engagement Report \(PDF 958 KB\)](#) (Ekosgen, 2024a)

Ekosgen, working with Education Scotland, undertook research with secondary schools across Scotland to identify key factors in successful STEM learner engagement. The research team undertook a series of consultations with identified schools, to explore the underlying reasons for successful STEM intervention. This

research used consultation approach with nine schools selected due to interesting practice, uptake of STEM, attainment in STEM and to ensure representation across gender, SIMD deciles, rurality, school roll, cluster size etc. Both staff, leaders and learners were engaged both in the BGE and senior phase. The report coupled this information with a desk-based analysis of the STEM pipeline, understanding pupil destinations. Full methodology is available in the report. The study was conducted in the context of Scottish Government's STEM Education Training Strategy Refresh, increasing focus on boosting STEM education engagement and participation, and growing the pipeline of STEM education skills.

The following summarises key findings arising from the work. These are critical factors that underpin improving and retaining the levels of STEM uptake, equality, equity and attainment in schools.

Findings included:

- The importance of project-based learning, interdisciplinary learning and out-of-class activities in supporting STEM engagement should not be underestimated.
- Refreshing the curriculum – Where reconsideration of the subjects and topics on offer within a school has taken place, there have been notable improvements to engagement and attainment in STEM.
- Where there is a broad level of support for STEM learning within a school's Senior Leadership Team, generally attainment and performance is better in these subjects.
- It has been found across the study that both challenge-focused activities and pupil-led initiatives (where pupils are at least partially responsible for the club) are the most well-received activities and lead to the highest levels of engagement.
- Creative use of Pupil Equity Fund (PEF) resourcing and creation of new pathways were the most common methods of retaining learners on the STEM journey, where the pupils came from deprived areas.
- New pathways (with greater focuses on practical learning) had also been developed in some schools, which had resulted in greater uptake in STEM subjects in cohorts from more deprived areas.

These two Ekosgen reports taken together, provide clear recommendations to create a more supportive and effective environment for STEM education, addressing the identified barriers (some of which are structural) and enhancing student engagement in STEM subjects. This report provides useful messages and evidence to inform the Sciences Curriculum Improvement Cycle, including the implementation phase.

[4.2.3 STEM Nation Award programme](#)

The STEM Nation Award programme (Education Scotland, n.d.-b) has been developed by Education Scotland to celebrate, promote and build on effective practice

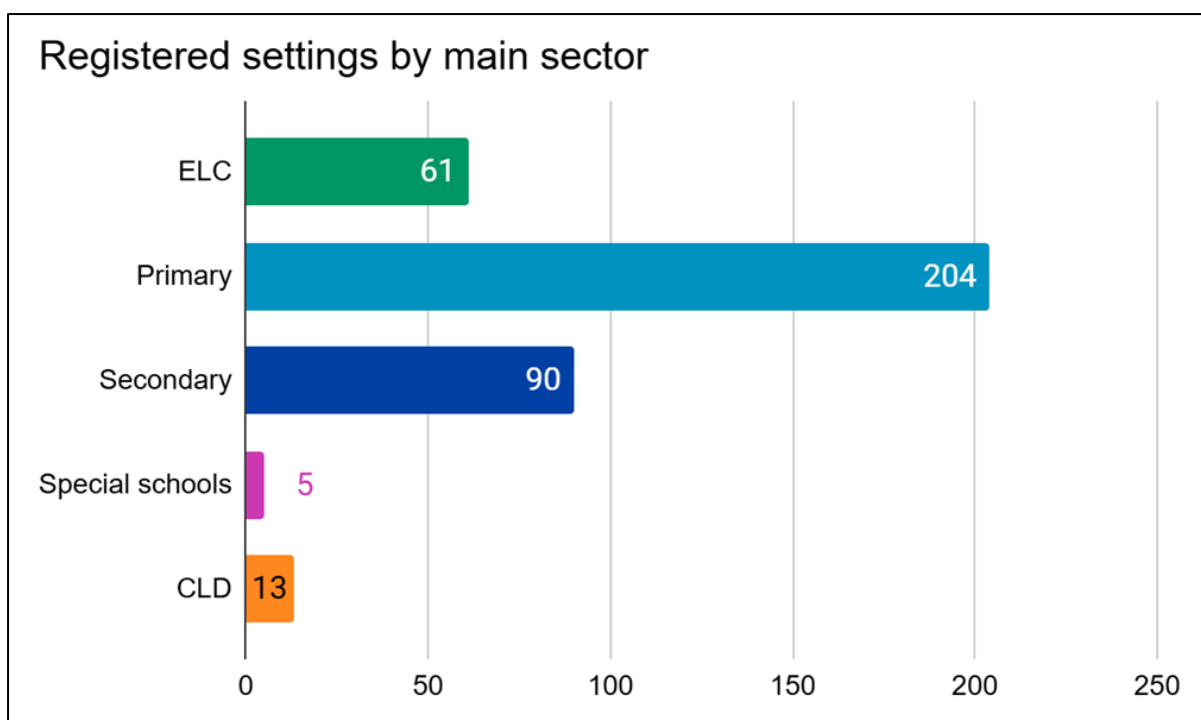
in STEM education within and across sectors. All early learning and childcare (ELC) settings, primary schools, secondary schools and providers of community learning and development (CLD) are eligible to apply for the STEM Nation Award. Settings may apply for an individual element or any combination of elements. Settings which achieve all five elements within a three-year period are eligible for the full STEM Nation Award after successfully completing a validation conversation.

The five elements are:

- Leadership in STEM
- STEM family learning
- Employability and STEM partnership working
- STEM curriculum and learner pathways
- Equity and equality in STEM

Following a successful pilot of Education Scotland's STEM Nation Award programme in academic year 2019/20 (information correct as of July 2025):

- 373 ELC settings, schools and CLD providers are registered for the award across 29 local authorities and the independent sector (as shown in figure 15).
- 60 settings have achieved the full award.
- Over 9,500 teachers have been reached through the whole-setting approach with further support provided for practitioners working in the ELC and CLD sectors.
- Over 129,000 children and young people have benefitted from STEM learning experiences in schools with even more children, young people and adult learners benefiting from STEM learning across the ELC and CLD sectors.



Graph 16 - Number of settings by sector who are registered for the STEM Nation Award (Education Scotland, 2025)

4.2.4 Evaluation of the STEM Grants Programme

Evaluation of the STEM Grants Programme Rounds One to Three (Year 3) (Ekosgen, 2024b)

The STEM Grants Programme (SGP) was launched in October 2018 to increase access to STEM learning opportunities, to build the capacity and confidence of practitioners, and to support the implementation of the STEM Education and Training Strategy for Scotland (see section [1.4 Related national policies](#)). The Programme was delivered across all education sectors: early learning and childcare (ELC), primary, additional support needs (ASN) and secondary schools, community learning and development (CLD), and school-based technical support staff. It aimed to deepen and extend subject knowledge to improve STEM learning and teaching and ensure that professional learning reaches new audiences and geographies and builds on existing STEM professional learning provision. The following is a summary of the evaluation of the SGP.

- Over four grant rounds, overall funding awarded was £4,576,251. This supported 307 projects and 3,102 professional learning sessions, reaching 69,349 practitioners and providing 196,090 hours of professional learning.
- The SGP has consistently delivered high quality learning (with 86% of respondents saying this was good or very good in the 2020/21 Ekosgen practitioner survey) and with 87% saying the level of expertise of the provider was good or very good.

- 98% of practitioners felt the SGP had improved their STEM learning and teaching capabilities, with 49% saying it had significantly improved.
- Almost half of all the practitioners surveyed in the 2020/2021 practitioner survey said the knowledge gained through supported professional learning benefited their whole school or setting (48%), and a further 18% said it would benefit their whole cluster.
- The 2021 survey of practitioners indicated that the SGP made a substantial difference to the practitioner understanding of the need to ensure equity and equality in their approach with learners. Although 40% said they were “very aware” of the need to ensure equity and equality in their approach prior to the SGP support, this increased to 68% following support.
- From the 2021 survey, more than eight in ten practitioners reported that learners had an improved understanding of STEM subjects (81%, 47% significantly so). Further, 77% report improved engagement with STEM amongst learners and 82% increased motivation to learn about STEM.
- Some 87% of practitioners believe that learners increased their attainment in STEM as a result of the SGP, almost a third significantly so. Practitioners also report that learners have enhanced STEM skills (84%) and improved performance (78%). More than half also think learners have more STEM-related job and career aspirations (54%).

4.2.5 STEM annual practitioner surveys

The findings included below provide the information about the state of STEM professional learning and the confidence levels of educators in delivering STEM education in 2022/23. There are also surveys available from previous years (dating back to 2016/17) [available here](#). These surveys provide longitudinal data between 2016 and 2023, over the lifetime of the STEM Strategy.

STEM (ELC/Primary/ASN/Secondary)	Professional Learning Survey	2022/23	Findings
(Education Scotland, 2024b)			

The survey included a wide range of practitioners, such as classroom assistants, senior leaders, and teachers from various curriculum areas, reflecting a comprehensive view of STEM education across different roles. Relevant key findings from the Annual STEM Practitioner Survey for ELC/Primary/ASN and Secondary 2022/23 include:

1. *Practitioner confidence:* Approximately 72.7% of respondents reported feeling 'confident' or 'very confident' in delivering STEM learning, which marks a 9.7% increase compared to the 2020/21 survey.
2. *Professional learning access:* The survey explored the number of hours of STEM professional learning accessed by practitioners, highlighting the importance of ongoing professional development in enhancing STEM education. Priorities identified for professional learning include:

- pedagogies and teaching approaches to deliver STEM learning effectively
- skills progression in STEM subjects
- developing the curriculum for STEM
- barriers to learning

The survey also identified barriers that practitioners face in accessing STEM professional learning:

- difficulty in finding staff cover
- difficulty in attending learning due to other commitments
- lack of funding to pay for professional learning

[STEM Professional Learning Survey 2022/23 Findings \(CLD\)](#) (Education Scotland, 2024c)

There were 30 responses to the 2022/23 survey for community learning and development (CLD) staff. Therefore, the information contained within this report is based on a small sample size and care should be taken when drawing comparisons or identifying trends.

Barriers were similar to other surveys summarised above. Priorities for professional learning in STEM were identified as:

- awareness about resources and support available for learning approaches to delivering STEM through a CLD context.
- understanding and applying digital skills within a CLD context
- how to lead and coordinate STEM within a CLD context

[STEM Professional Learning Survey 2022/23 Findings \(School Technical Staff\)](#) (Education Scotland, 2024d)

There were 76 responses to the 2022/23 survey for school-based technical support staff – most responses were from secondary support staff. The majority of technicians responding to the survey were sciences technicians. The majority of professional learning attended was delivered by SSERC followed by local authority and technician service centre. The main barriers to accessing professional learning were similar to the ELC/Primary/ASN/Secondary survey. The priorities for professional learning, however, were different:

1. health and safety update
2. sciences
3. skills progression in STEM subjects

These findings will be useful to bear in mind when creating the conditions for the new curriculum to succeed and for ensuring practitioners and technicians feel confident to implement it.

4.3 Curriculum Improvement Cycle pilot reviews

Sciences did not undertake a pilot review therefore no report is available. The reason for this is that the Education Scotland Sciences Team was heavily committed to a national programme of sciences events at this time, reaching 1200 practitioners across 13 events in 2023/24. Although the team did not formally engage in the Curriculum Improvement Cycle pilot reviews, the planned sciences events were used to engage practitioners and gather evidence and perspectives on the sciences curriculum and their hopes and expectations about the direction of travel. These events included practitioners from all sectors and provided opportunities to discuss the reimagining of the broad general education sciences curriculum, as well as areas relating to attainment, assessment and moderation.

5 Stakeholder reports and reviews

The following section outlines impact reports from a selection of key stakeholders associated with the science and STEM educational landscape. It is not exhaustive and is intended to provide an idea of the many stakeholders providing support and activities for STEM education in Scotland. It is also worth noting that the STEM stakeholder landscape has previously been outlined as being complex and at times, presenting issues and, at times can be overwhelming for settings (Scottish Government, 2017; Ekosgen, 2022). This section also includes specific reference to STEM in the early years and pupil voice.

5.1 Key stakeholder reports

The following section provides an overview of some of the current science and STEM provision within Scotland as well as related areas such as outdoor learning and interdisciplinary learning. It does this via summarising reports from stakeholders. Overall, these reports from key stakeholders demonstrate the huge amount of activity to support science and STEM education, ranging from professional learning on specific science topics, to outreach support and the development of creativity skills – essential for problem solving in the sciences. Each of these reports highlight different ways in which learners have been engaged, from awards to interdisciplinary learning approaches to empowered and upskilled teaching staff. Each stakeholder has found approaches that work successfully. The learnings from these, as well as how stakeholders support and enhance science education, should be considered in a future sciences curriculum.

5.1.1 Raising Aspirations in Science Education (RAiSE)

Taken from Year of RAiSE report 2023/24 (RAiSE, 2024).

In 2012, The Science and Engineering Education Advisory Group (SEEAG) report (Scottish Government 2012) highlighted the need for a focus on promoting the confidence and competence of primary teachers to effectively teach STEM education. RAiSE is a programme of Education Scotland, The Wood Foundation, Scottish Government, and participating local authorities which empowers primary teachers to develop and deliver motivating and engaging STEM learning experiences.

This is achieved through the appointment of local Primary Science Development Officers (PSDOs) for a period of 23 months who lead upon STEM strategy, professional learning, networking and partnership development, and bespoke support.

Practitioners respond to surveys which inform PSDOs' action plans, alongside their understanding of local need and context aligned with national drivers and priorities. Activities in 2023/24 included:

- outdoor learning professional learning linked to LfS including resource kits
- partnership working with Edinburgh University to explore DNA
- programme focused on exploring engineering and its principles – STEMgineers

- STEM on a budget professional learning exploring low to no-cost STEM resources
- workshops linking STEM with the curriculum
- working with Scottish Book Trust for STEM links to '[Read, Write, Count](#)' books

RAiSE in numbers (most up to date figures can be found [here](#)). Since the programme was established in 2016, the following interventions have been provided:

- professional learning events – 3696
- practitioner engagements – 36,260
- hours of professional learning – 78,919
- local authorities engaged – 27 (out of 32)
- RAiSE online resources views –14,426 (between 01 January 2024 and 18 June 2024)

The RAiSE online resources include:

- science and technology planning resources
- STEM context planners: These planners were created by teachers, for teachers to provide STEM learning activities for commonly taught contexts across early, first and second levels.
- STEM though stories
- STEM trails
- STEM on a budget

Each plan is linked to CfE experiences and outcomes as well as sustainable development goals and meta-skills.

Programme impact

The quotes below are from some of the practitioners who have benefitted from engagement with the RAiSE programme:

'There's a collaborative network that is set up moving forward with a dedicated space that they can go back and forward, share resources and share best practice.'

'Our PSDO was very visible – visible in our schools, but also visible to our parents because she's been along at parents' events.'

'The STEM leads have been fantastic and enthusiastic, and keen to upskill themselves.'

Through engaging with the RAiSE pilot, 71% of teachers have reported an increase in their confidence in relation to the pedagogy of science and 76% in relation to the content of science. More confident teachers have had a direct impact on learners with 87% of teachers reporting that the programme has enabled learners to experience challenge in their learning. 77% of teachers stated that they have seen pupils' aspirations increase regarding science and technology careers (Lowden et. al., 2019).

In subsequent RAiSE local authorities' confidence levels in science for primary practitioners increased from 70.3% in 2018/19 to 81.8% in 2022/23 (Education Scotland 2024b).

The RAiSE programme has been key to building the confidence of primary practitioners by providing professional learning, resources for use in the classroom and bespoke support. Consideration therefore needs to be given to how to best support non-science-specialist primary teachers and early learning and childcare practitioners with implementing an evolved sciences curriculum.

5.1.2 SSERC

Taken from SSERC annual report 2024 (SSERC, 2024).

SSERC is a local authority shared service which provides an advisory service for all the sciences, professional learning (PL) and advice for primary and secondary science educators and technicians plus resources to support practical/experimental provision within the sciences curriculum. SSERC also deliver the Young STEM Leader Programme and the STEM ambassador programme.

Professional learning:

SSERC provides professional learning for practitioners in subjects including: Biology, Chemistry, Digital Skills and Computing Science, Environmental Science, Mathematics, Physics, and Technology, catering to the needs of different education sectors. This includes newly-qualified teachers, early-career teachers, mid and late career teachers, and those undertaking a STEM leadership role within their centre.

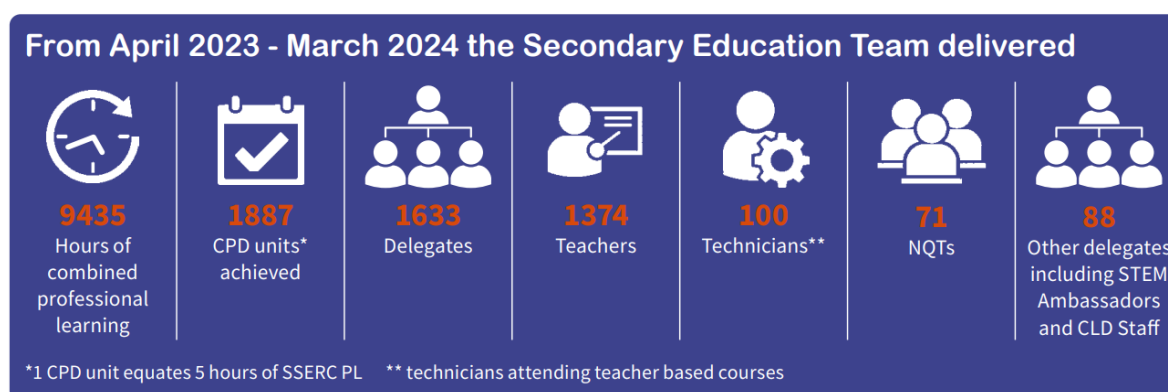


Figure 15 - Professional learning delivered by the SSERC secondary education team in 2023-24 (SSERC, 2024)

All courses delivered by SSERC were rated highly in evaluation in terms of their impact and usefulness.

Further courses for STEM leadership (GTCS accredited), early years, primary and ASN digital/computing skills were also delivered. The primary cluster programme and SSERC meets were also continued in 2023/24.

The primary cluster programme specifically reached:

- 1013 schools
- 186 clusters
- 9648 teachers/ early years practitioners
- 847 mentors and had a total of 24,162 attendees

SSERC also provides courses for technicians:

- 4580 hours of combined professional learning
- 916 professional learning units achieved
- 322 technicians
- 52 technician-specific professional learning courses

SSERC provides many other courses as well as bespoke professional learning – those included above are a snapshot of those with highest attendance.

Outreach work

SSERC's outreach work aims to respond to some of the ongoing challenges faced by education establishments such as staff release and shortage issues, limited budgets, and the need for environmental sustainability. They do this via localised professional learning delivery and the use of digital technology to support online delivery (live, pre-record or self-study). Online delivery has included 200,000 resource downloads and reached 31,609 website users in Scotland. Microbiological techniques and eye dissection were the top viewed videos.

Further detail on the type of courses, popularity and impact of these courses will be useful to inform the type of professional learning needed as the sciences curriculum evolves.

Advisory service

The advisory service provides specialist health and safety advice for schools and local authorities as well as professional learning on the topic. They also provide apparatus testing to ensure conformity with standards and risk assessments for various activities. Chemistry has the highest number of website visits for the advisory service.

STEM engagement

The Young STEM Leader Programme (YSLP) is an award that is free and open to all young people in Scotland. Supported by the Scottish Government and delivered by SSERC, the programme is built on a learner centred approach with young people encouraged to lead and develop STEM activities and share these, in an inspirational way, with an audience of their choice. Since 2019, 20,000 young people have engaged with the programme. The award begins at CfE second to fourth level, which are termed the non-formal awards. The formal awards are SCQF accredited, offering Insight points at SCQF Levels 4-6. The SCQF Level 7 award has been fully piloted throughout 2023/2024.

The impact of the award is that it:

- improves confidence and communication skills
- builds STEM capital
- creates positive STEM role models
- sets learning in context
- helps develop valuable attributes for life, learning and future careers
- encourages Learning for Sustainability
- supports interest and enthusiasm around STEM
- enhances leadership skills

Examining how the Young STEM Leader Award achieves this will be a useful consideration for a future sciences curriculum as these are all attributes that have been outlined as necessary.

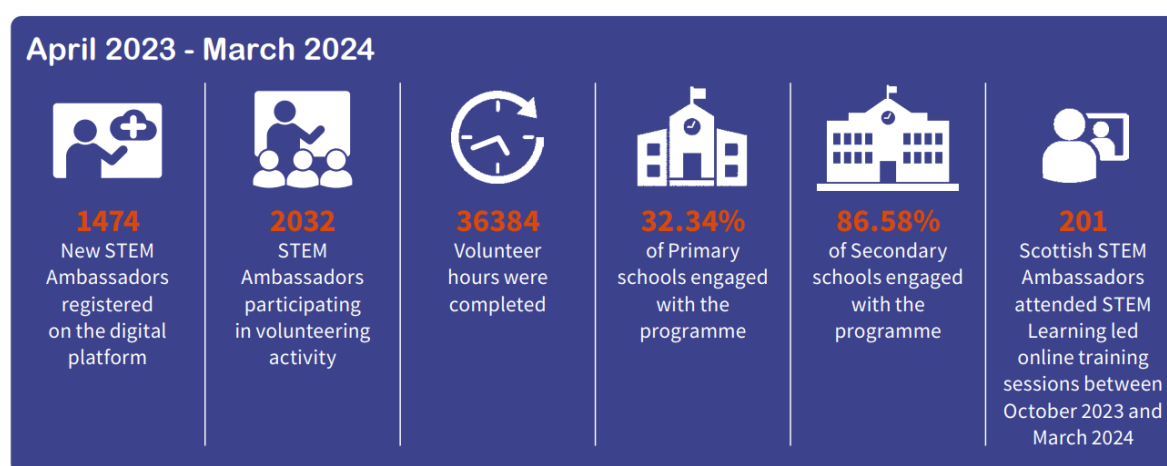


Figure 16 - Engagements carried out by STEM ambassadors in Scotland in 2023-24 (SSERC, 2024)

SSERC has many partners that enhance provision and provide support and funding.

5.1.3 Scottish STEM placement programme

SSPP (Scottish STEM Placement Programme) aims to connect educators and learners with industry and research through two-day placements in workplaces. These placements aim to highlight links between the curriculum and the workplace, as well as increase knowledge of STEM careers and pathways. Placements are with companies such as Merck BioReliance, Roslin CT, Charles River Laboratories, CPI, and Lifescan.

5.1.4 Stemovators

(Formerly known as Young Engineers and Science Clubs Scotland (YESC).

(Taken from Stemovators impact report 2023-24 (Stemovators, 2024).

In addition to STEM clubs, Stemovators now also offers engagement activities for classes, year groups and whole schools. The aims of these is to ignite curiosity and build skills in science, technology, engineering, and maths through exciting and engaging learning activities and the programme works collaboratively with schools to design programmes.

Over the year 2023-24 the programme engaged with:

- 7500 pupils and 200 teachers
- 10,000+ young people overall
- 29 local authorities

They also distributed 254 kits to schools and hosted seven regional celebration events, targeting rural and low SIMD settings (46 per cent).

Projects included:

- *Climate Smarter* – learners investigate how energy, building materials and water are produced, used, and how this is affecting the world around us.
- *Carbon capture and storage (CCS)* – learners explore the properties of carbon dioxide (CO₂) and the impact of excess CO₂ on our atmosphere as well as the full process of capturing, transporting, before identifying suitable storage sites around the UK.
- *Power path* – learners design and built a marble run to simulate subsea cables transferring electricity from renewable sources.
- *Rampaging chariots* – inspires learners to think like engineers and encourages them to adopt an engineering mindset by designing and constructing a competitive sports robot.
- *Lighting up the Curriculum for Excellence* – learners get the chance to construct their own electronic device using circuit kits.

Feedback showed that learners learned more about STEM pathways and that they enjoyed the activities. Teachers rated resources and professional learning highly and felt the projects linked well to careers and future skills.

5.1.5 Edina Trust

The Edina Trust is a small charity, registered in Scotland. The origins of the Trust's funds have led to an interest in funding activities which enhance the teaching and learning of primary school science. The Edina Trust offers £800 primary school science grants (over a three-year period) and £550 nursery science grants. It has funded 16 local authorities in Scotland since 2007. The funding can cover science weeks, visits, equipment, outdoor equipment and subscriptions. The trust also provides free primary science teaching resources on their website.

5.1.6 Science centres and festivals

There is a science centre in each of Scotland's four largest cities:

- [Aberdeen Science Centre](#)
- [Dundee Science Centre](#)
- [Glasgow Science Centre](#)
- [Dynamic Earth](#) in Edinburgh

In addition, the [Newton Rooms](#) facilitated by the Science Skills Academy (SSA) cover the Highlands and Islands and have a different approach to engagement to overcome any geographical challenges.

All science centres carry out engagement with schools via a combination of outreach, visits and professional learning for practitioners. These engagements have a variety of foci ranging from careers education to climate education. The science centres also reach more remote areas via partnership working and through the Science Skills Academy.

A summary of the impact and reach can be found below.

Aberdeen Science Centre *(Taken from Aberdeen Science Centre, personal communication, July 2025)*

- 8178 school visits (6981 pupils and 1197 teachers / supporting adults) took part in the [STEM learning programme](#).
- Provided targeted funding to allow learners from deprived and or rural areas of Aberdeenshire, Moray and Aberdeen City to visit.
- Worked with settings to identify and remove barriers to science participation.
- Teachers reported the visits had enhanced the curriculum offer via more varied practical activities.
- Developed new wind energy themed workshop (for P5-7) in partnership with Thistle Wind.

Dundee Science Centre

- In addition to the learning lab mentioned below (Glasgow Science Centre), Dundee Science Centre offers work experience to secondary school learners from Dundee schools. Sixty S3 learners took part in 2023-24.
- It also supported STEM clubs, school visits and outreach sessions.

Glasgow Science Centre *(Taken from their [Year in Review 23-24 report](#), Glasgow Science Centre 2024)*

- Supported a total of 62,000 education visits.
- Delivered learning experiences to young people across Scotland via *Learning Lab 'Powering the Future'* (together with Aberdeen Science Centre, Dundee Science Centre and Science Skills Academy). Engaged over 11,000 primary

and secondary learners (P5-S2) plus their teachers and families, in around 200,000 hours of learning.

- Through *Learning Lab 'Powering the Future'* – learners indicated an increased interest in science and could identify a range of career opportunities available to them. Teachers gained increased confidence in STEM, improved knowledge of the energy transition and increased awareness of careers in the field.
- 2,505 learners from across Scotland took part in classroom learning and hands-on workshops about a history meets science activity looking at how climate change affects Scotland's historic sites (in partnership with Historic Environment Scotland).
- Worked with JP Morgan, BAE Systems, Morrison Construction, Mathworks and University of Glasgow Living Lab to deliver inspiring careers workshops to over 2,400 secondary learners from Greater Glasgow as part of the STEM futures programme. Sectors including cyber security, fabrication, construction management, aerospace engineering, and precision medicine were explored.

Newton Rooms (Taken from their [Evaluation report](#) (Science Skills Academy, 2024))

- A total of 21,982 engagements were delivered during the period 2017 – March 2023.
- SSA project has engaged with 94% of schools in the Highlands.
- The pop-up Newton Room has proved particularly effective in overcoming geographical barriers for more rural and remote schools.
- The majority of learners rated their SSA experience very positively, and also thought that SSA activities made learning easier.
- The SSA project is considered a vital component of wider STEM education delivery across Highland.

Dynamic Earth, Edinburgh (Taken from their highlight report, *Dynamic Earth* (2025))

- Reached 45,175 learners with their school programmes.
- Delivered 715 early years storytelling and hands-on workshops.
- Connected 16,603 learners with practicing scientists in research and industry with their Meet the Scientist programmes.
- Doubled the reach of 'Your Planet, Your Future! Careers' event to over 1,500 people.
- Reached learners across every local authority in Scotland.

Edinburgh Science Festival (*Edinburgh Science, n.d.*)

- Generation Science programme travelling teams visited 314 primary schools across Scotland – from the Scottish Borders to the Shetland Isles – delivering 790 STEM-themed workshops and shows to primary school children.
- The programme uses SIMD to identify areas most in need and takes a science capital approach to try and address educational inequality.
- *Careers Hive event* welcomed 2,481 learners from 13 local authorities, 155 teachers, 119 volunteers and 10 panel speakers to the National Museum of Scotland.

- The event had three main activities: Experience STEM exhibition, Skills Gateway Workshop and Life After Leaving School panel discussion.
- 87% of attendees said they gained a better understanding of jobs available in STEM, 66% are more interested in studying STEM subjects and working in STEM-related jobs and 91% of learners enjoyed coming to Careers Hive.

5.1.7 Nature Scot

[Teaching, Learning and Play in the Outdoors: a survey of provision in 2022](#) - Nature Scot (2022)

The report offers an in-depth picture of teaching, learning and play activity, provided by staff working in 19 early years centres and 25 primary schools.

The provision of outdoor learning and play in early years education in Scotland has increased compared to 2014 survey findings, rising from 36% of the day spent outdoors in 2014 to 39% in 2022. It continues to focus strongly on play and shows a small increase in off-site provision in woodland locations. Figures for primary school children, however, show a decrease from 24 minutes per pupil per week in 2014 to just 7 minutes in 2022.

While outdoor learning continues to be seen by teachers as curriculum-enhancing and enjoyable, considerable numbers of practitioners across primary and early years lack confidence in offering it, with early years practitioners reporting higher confidence levels than primary teachers for both outdoor learning and Learning for Sustainability.

Health and wellbeing, science and mathematics are the top curricular areas. 'Practical activities', 'teamwork', 'nature' and 'play' were the main foci.

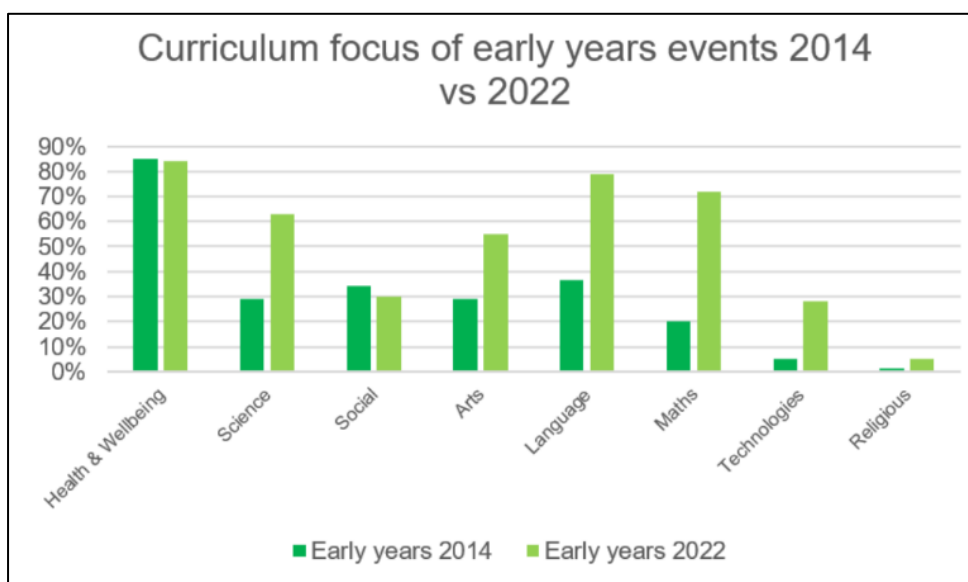


Figure 17 - Curriculum focus of early years outdoor learning activities 2014 vs 2022 (Nature Scot, 2022)

[Dunkley](#) (2022) also cites the role of citizen science in education for sustainability.

The recommendations include expanding the provision of outdoor learning and play. Support needs to be provided to practitioners to help raise their confidence as well as making use of a variety of outdoor spaces (close to and further away from the setting). Lastly, further research is required to understand the provision of and benefits of outdoor learning.

The implications for the Curriculum Improvement Cycle are to ensure outdoor learning is a planned and integral part of the sciences curriculum.

5.1.8 Daydream Believers

Taken from their [impact report 2023 – 2024](#) (Daydream Believers, 2024).

Daydream Believers is a not-for-profit education organisation focusing on placing creativity at the heart of education. They develop free, ready-to-use, online resources for educators that utilise creativity, critical thinking and problem-solving techniques applicable across the curriculum and beyond. Daydream Believers also offers the Creative Thinking Qualification at SCQF levels 5 & 6 (24 SCQF credits). Level 6 also has 36 UCAS tariff points. They offer a 30-hour professional learning course on Creative Thinking for teachers in collaboration with the Glasgow School of Art.

The impact report outlines the positive impact their resources and project-based challenges have had on learners and teaching professionals alike. The benefits are myriad, ranging from improved wellbeing and engagement, to improved attainment through their creative thinking qualification. All projects have a future thinking, fail and fix approach helping to build resilience in learners and key skills required for the future. Via their interdisciplinary nature, the projects successfully incorporate science and STEM knowledge and skills. This enables learners to apply their learning in these areas to unfamiliar contexts.

Daydream Believers in numbers:

- 95 schools
- 27 local authorities
- 200+ teachers ([feedback from teachers](#))
- 6000+ learners (3280+ aged 5-15 engaged in BGE resources)
- 96% of teachers report an increase in their engagement and enthusiasm for learning and teaching
- 97.4% positively impacted from working on the Creative Thinking qualification

Daydream Believers has also been recognised by the Scottish Government for leading the advancement of inter-disciplinary learning (IDL) in education, helping to integrate creativity and critical thinking into the national curriculum. They have also encouraged exploration of AI's potential, helping educators embed AI into creative thinking and across the curriculum via their Gen AI travel guide.

The hugely positive feedback and the embedding of creative thinking applied to real life, project-based learning are significant for the sciences curriculum. The approaches used and resources created by Daydream Believers will be useful when considering

how to do this for an evolved sciences curriculum, how this could be assessed and providing engagement for learners and teachers alike.

5.2 Subject associations

This section refers to three Learned Societies relating to science: Institute of Physics (IOP), Royal Society of Biology (RSB) and Royal Society of Chemistry (RSC). It also includes references to the Association for Science Education (ASE). They have published many research and evidence informed papers on science education. For this evidence paper, only those that refer to curriculum recommendations will be included.

This summary provides an overview of the recommendations from three learned societies groups: IOP, RSB and RSC. As well as this, recommendations from the Primary Curriculum Advisory Group (PCAG) which was set up by the IOP, the RSB, the RSC and the ASE in 2019 is also included.

The summary for each of the reports follows the same format:

- introduction
- outline of methodology
- outline of the recommended framework
- further detail on the specific big ideas for each science discipline
- recommendations for how the frameworks could be successfully enacted

As this is a summary document, intended to provide top lines, it may be that detail is lacking in places. The full reports are hyperlinked and available to view within the document. Where it would be particularly helpful to explore in more detail, page references and/or specific diagrams have been signposted to. Following an outline of each report, a summary of similarities and differences will be made.

5.2.1 Primary Curriculum Advisory Group

[Developing a Primary Science Curriculum: Recommendations based on the Primary Curriculum Advisory Group's Framework](#) (ASE, IOP, RSB and RSC, 2024)

Primary Curriculum Advisory Group (PCAG) was set up by the IOP, the RSB, the RSC and the ASE and asked to provide advice about the future of the primary science curriculum (3-11 years). This report includes recommendations from the PCAG. It draws extensively on evidence from a wide variety of research sources and from many additional experts in the field. The recommendations are bound by a set of criteria that justify the knowledge to be included.

These state that the knowledge included:

- will prepare children to be responsible global citizens
- is necessary for understanding wider aspects of the curriculum
- is appropriate for children's age, interests and stage of development
- is necessary for them to progress further in learning the sciences

The overarching vision is for all children to flourish and take their place in the world as informed and responsible citizens, ready and able to meet the global challenges of sustainable and equitable living.

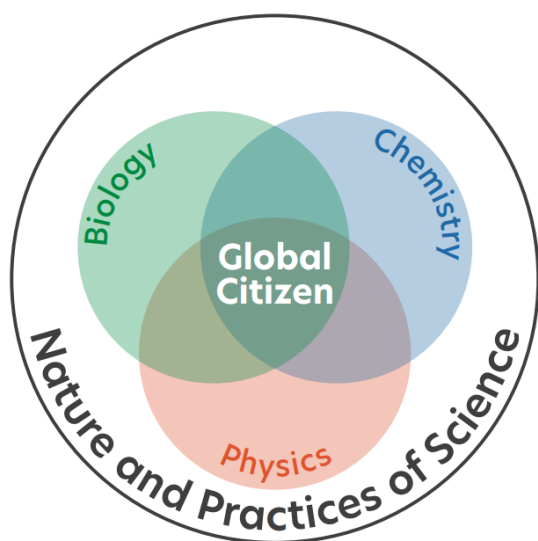


Figure 18 - PCAG framework consisting of four knowledge maps (ASE, IOP, RSB and RSC, 2024)

This PCAG Curriculum Framework consists of four knowledge maps:

- PCAG Knowledge Map for the Nature and Practices of Science is about children gaining first-hand practical and enquiry experiences and can relate these explicitly to why they are undertaking them.
- Three subject knowledge maps – PCAG Knowledge Maps for Biology, Chemistry and Physics, which include key features:
 - understanding for global citizenship
 - subject knowledge children need by age 11
 - equity and inclusion; essential experiences that all children must have by age 11
 - conceptual boundaries: to support parity across all ages and levels, support progression and consider cognitive developmental stages

This curriculum framework is structured to give educators a clear understanding of the purpose of everything that the children will be learning, and to enable them to make this explicit to the children themselves.

The first knowledge map – the Nature and Practices of Science is outlined as below.

The nature and practices of science:	This knowledge underpins children's understanding of how:	Equity and inclusion: all children should be taught to:
Science is universal, has been and is carried out in all cultures at all ages, creating a diverse scientific global community.	scientists apply what they know to inform decisions and solve problems related to local and global challenges.	apply their scientific knowledge and findings to different contexts and problems, including personal, local and global.
	science began before the European Renaissance, and has taken place across history and the globe.	- value and respond to the contributions of others within and beyond their own community. - learn about scientific endeavours throughout history with examples from different cultures and historical periods.
Science is a creative human endeavour which builds new knowledge to explain natural phenomena.	scientists make inferences, are curious and imagine possibilities.	be curious, demonstrating a passion for discovery, imagining possibilities.
	- scientists observe to ask and answer scientific questions to build explanations about the natural world. - scientists work through an iterative enquiry process, in which answering one question often leads to other questions.	- ask, plan and answer their own scientific questions to explore possibilities and help explain the natural world. - identify new questions that have arisen from an enquiry.
Science is an empirically based process (based on or derived from observation of the natural world).	scientists make observations and collect, analyse and interpret data to test their ideas.	gather data by making and recording observations and measurements.
	scientists identify links, patterns and relationships.	- analyse data to identify links, patterns and relationships. - understand how to differentiate between questions that science can or cannot answer.
Scientific knowledge is tentative and subject to change based on new evidence or new interpretations of existing evidence.	scientists present and explain their ideas and evidence, are receptive to new ideas and may not always agree with each other.	present and explain their findings to a range of audiences, inviting peer-review on their conclusions.
	scientists are sceptical, develop their ideas by using what they already know and new evidence.	review and question their own ideas and understanding, as well as those of others, to appreciate that over time, areas of science can change and develop in response to new evidence.
Science is a rigorous discipline where it is important to know how the evidence was collected and whether it can be trusted.	scientists adhere to the accepted methodologies of enquiry and answer different types of scientific questions.	use different enquiry methods to answer scientific questions.
		design and evaluate enquiries in order to maximise the trustworthiness of their data.

Figure 19 - PCAG Knowledge Map: Nature and Practices of Science (ASE, IOP, RSB and RSC, 2024)

In 2024, ASE, IOP, RSB and RSC accepted the recommendations in the PCAG report and published an extract alongside joint recommendations in Developing a Primary Science Curriculum. The Societies highlighted main messages from the PCAG framework: global citizenship, inclusion, contexts, essential experiences and conceptual boundaries, guidance for primary teachers, and five recommendations for policymakers and curriculum developers.

Recommendations

Our recommendations to policymakers and curriculum developers are as follows. The primary science curriculum should:

- 1** have a strong emphasis on purpose, considering not just what is taught and learned, but why and how, so that children develop a coherent and cognitively appropriate understanding of how the world works and their own agency within it;
- 2** help children identify with the sciences by providing opportunities for teachers to choose contexts that are relevant to their pupils;
- 3** help all children to feel included in the sciences through the experiences that they have, and the perspectives put on science narratives and by encouraging teachers to use contexts that are familiar to primary age children;
- 4** ensure the curriculum plans for progression to avoid content being taught before it is appropriate for the age/development stage of the child;
- 5** encourage children to think scientifically, to discuss and explain their thinking and, through practical experience, gain a sense of the nature and practices of the sciences.

Figure 20 - PCAG recommendations to policy makers and curriculum developers (ASE, IOP, RSB and RSC, 2024)

The maps for Biology, Chemistry and Physics provide more detail about understanding for global citizenship, the scientific knowledge children need by age 11, essential experiences all children must have by age 11 and the conceptual boundaries. They can be found within the [PCAG curriculum framework recommendations document](#).

Since these curriculum recommendations are underpinned by global citizenship, strongly related one of Scotland's four capacities (responsible citizens), it would be useful to acknowledge how the curriculum content they have suggested can explicitly develop global citizenship as well as intend to promote equity.

5.2.2 Institute of Physics (IOP)

[The fundamentals of 11 to 19 physics: Overview](#) (Institute of Physics, 2024)

The Institute of Physics (IOP) has been considering how best to design a physics curriculum that is fit for students in the 21st century. Having worked with teachers, teacher educators, physicists and education researchers, they have developed a framework for designing a physics curriculum 11-19, based on the practices and big ideas of physics.

The recommendations for design of a physics curriculum are broken down into four design principles as follows:

- A. The big ideas of physics
- B. The practices and ways of thinking of physics
- C. Characteristics of the endeavour of physics
- D. Applications and contexts

The recommendations are:

- That curricula be built on explicit statements of some big ideas of physics, its practices and ways of thinking, and the characteristics of the discipline.
- The amount of content should be realistic and allow space in the curriculum to explore the big ideas deeply and to develop capability in the practices and ways of thinking. This space will also allow teachers to illustrate the applications of physics and provide local and personal contexts.
- The curriculum should ensure that physics discoveries can be framed in the historical context of the time that they were made (this includes historic contributions to the sciences from around the world, as well as the cutting-edge contemporary research produced by diverse teams of scientists).
- Students' experience of physics should be as authentic as possible:
 - they should have frequent opportunities to carry out practical work and investigations
 - they should use mathematical analyses
 - they should have frequent opportunities to experience and use the ways of thinking and reasoning of physics

Included in the recommendations are the purposes of studying physics at school, aims of a physics curriculum and considerations of how a physics curriculum can meet the needs of all students. This is done by considering what a physics curriculum should look like for those who may not go on to further study and suggests that, rather than having a fleeting, superficial grasp of a multitude of detailed facts, they will have a lasting general understanding of some of the important ideas of physics. The hope is that, at the very least, they have a lasting grasp of the cultural significance of those ideas (from physics) and are able to identify and follow discussions relating to them a long time after they stopped studying physics.

In the table below are a summary set of statements under headings for each of the design principles (taken from the report page 12). Alternatively, a visual map of the big ideas is available within the document on page 13. IOP have added that they would not expect the statements in sections C and D of table 1 to be assessed formally in the current system. Appendices provided in the report also outline age-related foci of each of the domain-based big ideas.

Lasting knowledge and capability from physics A. Big ideas Students should develop a lasting and deep knowledge and understanding of the following big ideas: i. Cross-cutting 1. Reducibility: explaining phenomena by identifying the constituents of a system and considering the mechanisms and processes that describe their behaviour. 2. Equilibrium occurs when two or more external influences are in balance (statically or dynamically). 3. Change is caused by a difference (in pressure, concentration, electric potential, temperature, etc). 4. Conservation: The idea that the amount of some quantities (e.g. mass, energy, electric charge, and momentum) are the same after an event as they were before; and this provides physicists with extremely powerful analytical tools. ii. Domain-based 5. All matter is made of very small particles and this helps us to explain many behaviours of matter. 6. Atoms are not indivisible – they have their own internal structure. 7. Objects interact with each other (by contact or at a distance) – giving rise to pairs of forces 8. All matter emits radiation in a spectrum of electromagnetic waves. 9. The Earth and planets orbit the Sun, one of billions of stars in our galaxy, which is one of billions of galaxies in the Universe.	10. An object will continue moving without a net force acting on it: it has inertia. 11. Charge is a fundamental property of matter and this helps us to understand electrical properties and effects. 12. Fields are regions in which an object may experience a force. 13. Electricity and magnetism are two facets of a single phenomenon: electromagnetism. 14. There are two ways to change the energy stored in a system: by working on it or heating it. 15. Dissipation: every event results in greater disorder if we take everything that is involved into account. B. Practices and ways of thinking Students should develop, by experience, a lasting capability in the following practices and ways of thinking: 16. Procedural knowledge: proposing and testing explanations of phenomena; making measurements and observations and verifying explanations of phenomena through experiments 17. Attitudes of physics: thinking critically, working collaboratively, seeking deep understanding and consistency in explanations, setting aside preconceptions, and facility with scientific language. 18. Thinking and reasoning techniques: to solve problems and refine explanations using critique and logic. 19. Models and systems: defining systems and using models to think with and to make predictions 20. Quantities and relationships: using relationships that recur across physics. 21. Numerical and mathematical techniques: using numerical and mathematical techniques to analyse situations quickly and make predictions.
Enduring impressions of physics C. Characteristics of the endeavour of physics Physics and its practices should be experienced and presented in a way that develops an enduring impression that the ideas, explanations and theories of physics are: a. Fundamental and universal Physicists aim to provide explanations and theories that go beyond the superficial and can be used as widely as possible; in all situations: the laws of physics apply across the universe – from the very large to the very small. b. Reducible Phenomena are often explained by reducing a system to its constituent parts and considering the behaviours existing those parts using a small number of existing ideas. c. Synthesised and consistent Physicists use ideas from across physics to develop new explanations; these must be rigorously consistent within themselves and with all other areas of accepted physics. d. Empirical and based on measurements Physics is based on evidence rather than intuition or belief. Physicists generally go beyond observing phenomena qualitatively; they define measurable quantities and make measurements of them in carefully designed experiments. e. Reasoned and logical Physicists use reasoning (deductive, inductive and statistical) to analyse data and develop convincing explanations that are consistent with the evidence. f. Based on systems Physicists define systems (collections of objects that interact) that are of interest and simplify them to their core elements.	g. Modelled Physicists develop models to help account for the observed behaviours of objects and systems. h. Mathematical and predictive The defined quantities enable physicists to develop verifiable quantitative relationships. i. Severely tested and reliable Physics models are used to make precise numerical predictions that can be tested – enabling a model to be rejected or supported. The accepted theories, laws and models of physics have survived severe and repeated testing. j. Open to revision Although reliable, physics explanations are always open to revision and improvement if there is evidence that brings them into question. k. Collaborative and global Physicists often work in teams across the world; our system of measurement enables ease of communication between communities of science practitioners. D. Applicability and context The substantive knowledge should be set in context to provide lasting knowledge that: l. Physics ideas can be applied and add value in other domains of study that are both within the sciences and outside them. m. Physics ideas are important when considering society's big questions and tackling its big challenges, such as climate change. n. Physics ideas enable engineers to improve our comfort and wellbeing by designing solutions to defined problems. o. Studying physics is preparation for many important, productive and rewarding occupations.

13

Figure 21 - Recommended design principles for a Physics curriculum (11-19) (IOP, 2024)

The IOP suggest that the sequence of the curriculum is most likely to be based on the big ideas, so the main structure of teaching schemes will likely follow those used previously. However, the difference will be the way in which the substantive knowledge is represented and taught. As well as learning the substantive content, students will also acquire knowledge and capability, through experience and active participation, in the other aspects of physics. They state that it is very much about evolution, not revolution.

For example: the practices and ways of thinking (as outlined in table above), will help curriculum designers and teachers to weave experiences of them into their teaching of the big ideas. By experiencing and using the practices and ways of thinking, students will not only develop lasting capability in them, they will develop the notion that physics ideas and explanations are securely based on observation and reasoning. In turn, it is hoped that such knowledge will give them enduring confidence in the ideas and explanations of physics. Page 17, Figure 2. of the document further exemplifies this by linking the design principles to the aims via the way in which the curriculum is taught.

The report finishes by recommending approaches to implementing curriculum change, outlining some of the practical considerations, further detail of which can be found in the report:

1. Physics should be taught and experienced in an inclusive way; as noted, the curriculum and teaching should frame the development of physics ideas within global and historical contexts; however, it is also essential that teaching approaches and the school environment are actively inclusive.
2. From the age of 14 (or before), physics should have its own identity with dedicated specialist teachers and identifiable timetable slots.
3. Both the design and the ongoing development of the physics curriculum should draw on expertise from outside (as well as within) awarding bodies, it should include curriculum experts, and it should seek and make use of evidence of what works.
4. Any reform to the physics curriculum should be backed up with sufficient funding to provide resources and professional learning and development opportunities for teachers and technicians.
5. Assessment schemes should be designed to encourage and support good practice in teaching and learning.

[The fundamentals of 11 to 19 physics: Further Details](#) (Institute of Physics, 2024)

This paper outlines the design principles and shows how they will result in achieving the aims stated in paper 1. This provides more of the detail of curriculum design.

5.2.3 Royal Society of Biology

Evolving 5-19 Biology – Recommendations and framework for 5-19 biology curricula (Royal Society of Biology, 2021)

The framework and recommendations for a future 5-19 biology curriculum was developed by the Royal Society of Biology (RSB) via proactive engagement with the bioscience and education communities. The Society's framework has been informed by research and evidence, and with the involvement of a range of experts to set out a way of exploring biology throughout 5-19 and beyond, creating a framework that the RSB believe is contemporary, durable and flexible. The framework outlines progression through biology knowledge content and practical skills development between the ages 5 and 19. The suggested framework overlaps with and feeds into primary recommendations above and several members of the PCAG group had sat previously on a primary working group at RSB contributing to the development of Evolving 5-19 Biology. The methodology is also similar.

The framework details three dimensions of biology:

- biology as a science
- core concepts of biology
- biology in the world

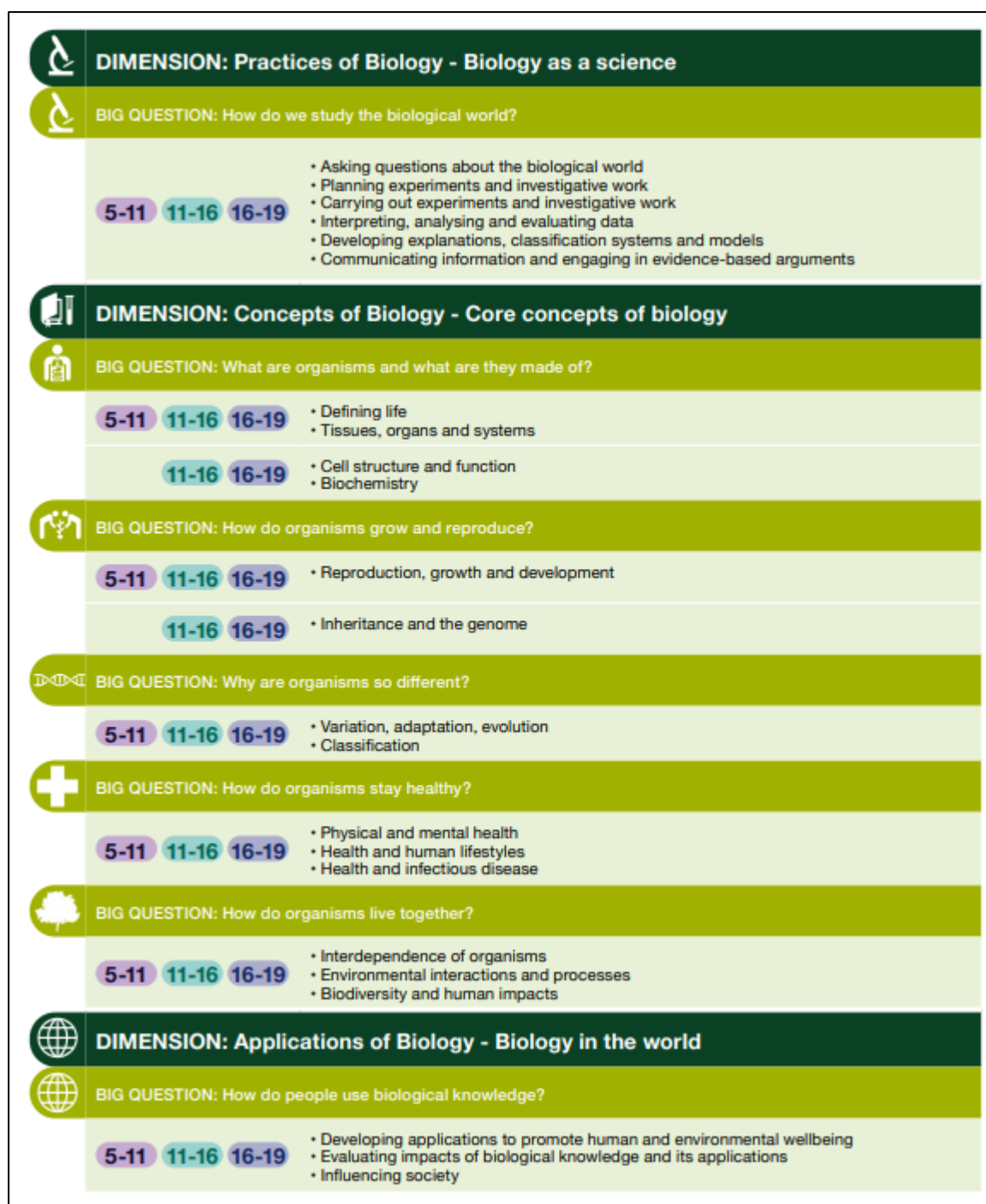


Figure 22 - Recommended framework for a Biology curriculum (5-19) (RSB, 2021)

Within these dimensions, pupils explore 23 key themes that seek understanding of, and answers to, the seven big questions of biology. It then goes on to outline eight recommendations to allow this to happen effectively.

The biology curriculum should:

1. Aim to develop pupils' understanding in the three dimensions.
2. Aim to develop pupils' understanding of big ideas of biology to answer big questions in biology.
3. Enable coherent learning progression from age 5 to age 19 via curriculum content that is set out in policy and guidance documents.

4. Provide pupils of all ages with ample opportunities to engage in practical and investigative work, including in the field.
5. Provide pupils of all ages with ample opportunities to learn about plants and other organisms, in addition to humans and other animals.
6. Draw upon previous curriculum development work and evidence from research, where appropriate to inform the development of biology curriculum policy, guidance and content.
7. Provide curriculum content set out in policy and guidance documents that is clear, teachable and assessable, while allowing scope for innovation in delivery.
8. Be contemporary yet durable.

Sitting alongside the framework is an exemplification detailing how the content of the national curriculum for ages 5-11, 11-16 and 16-19 could be organised according to the 'big questions' of biology. The RSB's framework and recommendations have been designed to be sufficiently future-proofed to reduce the need for regular updates of the curriculum, and the accompanying disruption this causes in schools.

They emphasise it is a framework not a ready-made curriculum and should be used as a starting point within the context of the nation and curriculum or specification intentions. For example, RSB has used the framework to inform more specialised qualifications e.g. revisions to Higher Human Biology, applied science qualifications and technical qualifications in England. The rest of the document is organised to outline the purpose of biology, the aims and vision for this document, methodology for development and then further detail exemplifying the visual framework above by age.

Recognising that some areas could benefit from further exploration, or a level of detail not possible within the framework document, RSB is developing a suite of documents that sit around the overarching framework document. The Society intends to expand this suite of documents e.g. a deep dive into mental health in the curriculum or teaching order of evolution and inheritance based on research by its member organisations. In 2024 RSB published short explorations into four areas of the curriculum that are often overlooked:

- [The role of practical activities in Biology](#)
- [Sustainability education](#)
- [Transferable skills in biology education](#)
- [Improving teacher and student perceptions of ecology](#)

Further information can be found at www.rsb.org.uk/curriculum

5.2.4 Royal Society of Chemistry

The elements of a successful chemistry curriculum (Royal Society of Chemistry, 2020)

In 2014, the Royal Society of Chemistry set up a Curriculum and Assessment Working Group (CAWG) to consider the provision of chemistry education throughout school years. The aim was to develop a curriculum framework that progresses coherently through primary and secondary schooling, by examining the evidence on best education practice and drawing on the expertise of a diverse range of representatives from the chemical sciences community (including testing ideas with teachers and other educators).

RSC state that the 11–19 curriculum framework presented in this report is designed to allow learners to encounter a wide range of modern chemistry, to demonstrate both its impact on everyday life and its potential to address some of the major problems facing society in the 21st century. They propose that the framework provides sufficient flexibility for curriculum developers to design courses suitable for all learners regardless of qualification pathway, across the UK and Ireland. Similar to RSB, they emphasise the framework presented represents what they see as the core of an ideal chemistry curriculum, but by no means its totality. Since the RSC were the first of the Learned Societies to publish this paper, they shared findings with the RSB and the IOP.

Guiding principles underpinning the curriculum framework were devised:

- A clear framework or narrative that gives a coherent ‘big picture’ of chemistry as a subject, explains why it matters, and shows how different areas of content are connected.
- Clear progression, in which deepening understanding is built on a secure foundation in each aspect of the framework.
- Encourage understanding of fundamental principles (as opposed to surface learning of facts). This promotes deeper conceptual understanding and the ability to apply learning to novel situations.
- Incorporate the procedural knowledge; and skills, (including practical skills), that are core to the discipline of chemistry.
- Be informed by the available evidence, including findings from research, best practice, and views from informed stakeholders.

In using this framework, it is also important to ensure that fully developed curricula offer:

- Appropriate alignment with the wider curriculum in related subjects.
- A defined learning entitlement that sets out clearly the level of understanding and skill that learners are expected to achieve at each stage.
- A level of demand that is aspirational but also allows an educational experience that is inclusive of all learners.
- A considered amount of prescribed content, to allow time within the curriculum to develop understanding and the flexibility for teachers to introduce meaningful contexts and applications that demonstrate the breadth of chemistry and its contribution to society.

Similar to the RSB, the framework details three dimensions of chemistry and explains how chemistry as a discipline can only be understood through the relationship between them.

These are:

1. Chemistry and the world (how chemical practices and concepts are used and how they impact society and the world)
2. Chemistry as a science (approaches to reasoning and inquiry)
3. Chemical concepts (fundamental understandings of the material world)

The visual below further expands on these concepts:

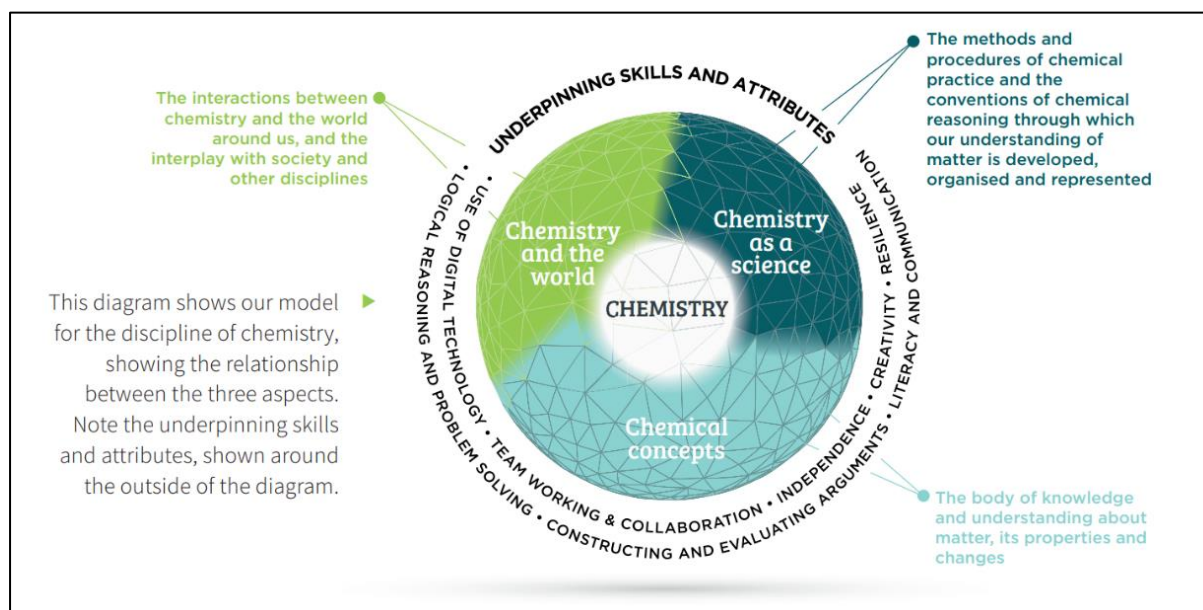


Figure 23 – Recommendations for three dimensions of chemistry for a chemistry curriculum (11-19), (RSC, 2020)

Sitting underneath this structure is another level which includes a set of 'Big Questions'. These aim to identify key ideas the RSC believe all learners should encounter by age 16. They emphasise that these key ideas should not be viewed as teaching topics or suggestions. Rather they are an indication of the core ideas that need to be understood to answer each Big Question. The RSC believe that using Big Questions as a narrative framework supports development of a coherent curriculum, as content – both knowledge and skills – can be selected to answer each question. It is hoped from this, that both teachers and learners can see the relevance of what is being taught.

The following diagram shows how these big questions are added onto the three dimensions outlined above.

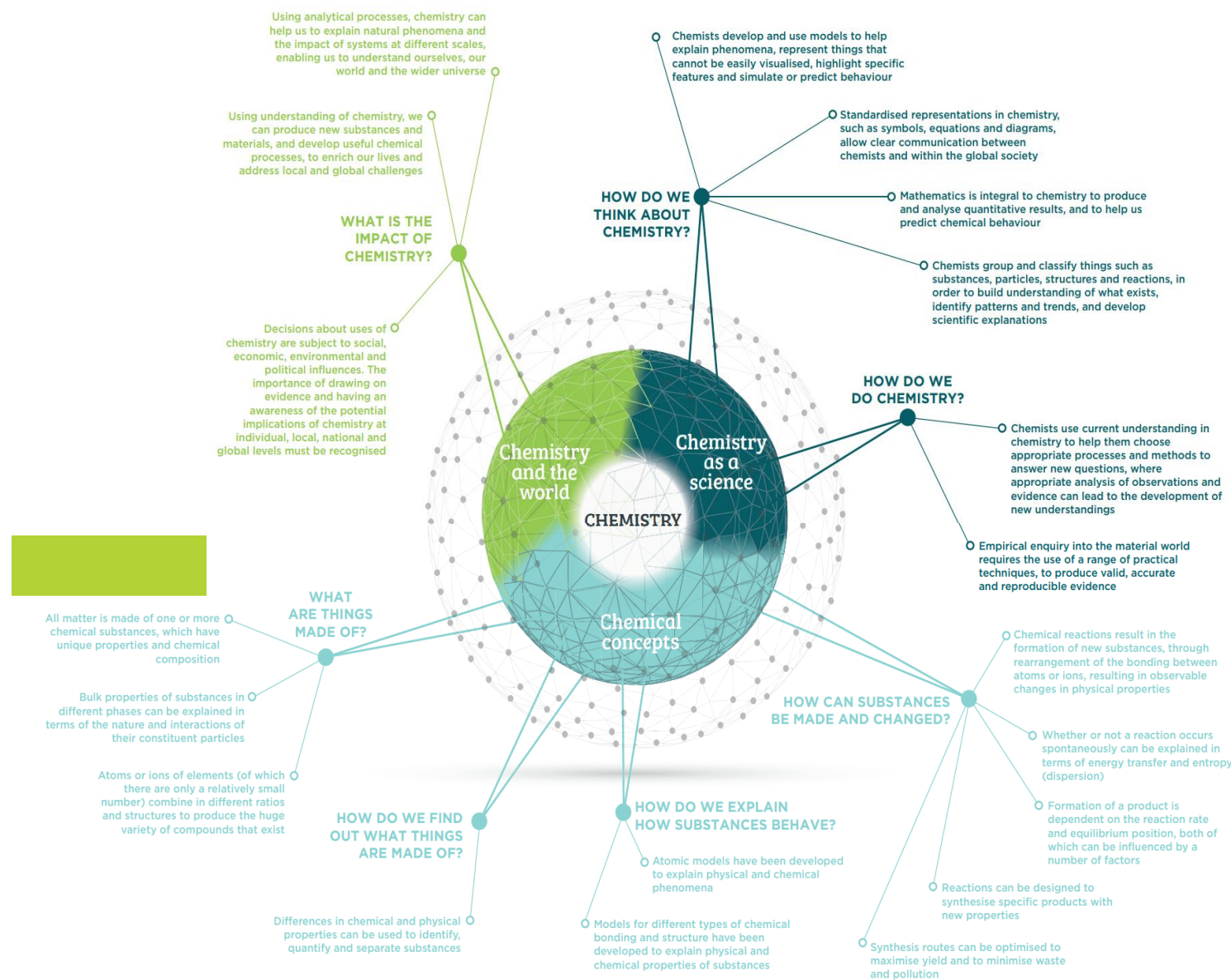


Figure 24- Recommended framework for a Chemistry curriculum (11-19) (RSC, 2020)

A further diagram also illustrates the connections between the areas but has not been included here. It can be found on page 9 of the paper.

It finishes by highlighting the importance of practical skills, and whilst not explicitly mentioned in the framework, should be understood as a core part of answering the question ‘how do we do chemistry?’.

The RSC report finished by outlining the of aims of the chemistry curriculum for each education stage:

- **5-11:** Lay the foundations of chemistry education within a science framework, in terms of scientific knowledge, skills and enquiry. Learners start to become informed about the part that science plays in the world around them.
- **11-16:** Provide a broad and balanced chemistry education for all learners, including about the role of chemistry in the world around them. Prepare learners who wish to pursue either an academic or a technical pathway.
- **16-19:** Prepare learners for further study on academic or technical pathways and careers related to chemical sciences, through developing essential skills and embedding a secure knowledge.

Since each of the Learned Societies has now published their research and evidence informed recommendations for Physics, Biology and Chemistry curricula, similarities and differences can be identified and used in the Curriculum Improvement Cycle for sciences. Furthermore, the proposed content included in these reports can be used as provocations for discussion. All three reports propose a big ideas approach with similarities in the core purposes of science education:

- knowledge and understanding of the world and how it works
- development of practical skills and scientific process and the influence these have on the world and society
- how do scientists do science: the practices and ways of thinking

Where they differ is in the level of detail and prescription and the age groups they provide recommendations for. This may in part be due to some being published prior to the Framework for a Future Primary Science Curriculum (Primary Curriculum Advisory Group, 2023).

The Royal Society of Chemistry also carries out an annual Science Teaching Survey. The most recent survey (RSC, 2024) showed 38% of Scotland-based science teachers who were surveyed named a shortage of technicians as having a detrimental effect on student learning outcomes in the year 2023-2024. In addition, 47% of science teachers and technicians surveyed said they felt they were understaffed when it came to science technicians. In 2018, SSERC also showed that school technician numbers have fallen by over a third since 2005, from 1,431 to around 900 (TES, 2018). 63% also listed insufficient school funding as having a detrimental effect on student learning outcomes.

5.3 Professional associations

As far as we are aware, there is no evidence for sciences from professional associations, including the main teaching unions.

5.4 Other relevant reports and reviews

5.4.1 STEM in the early years

In a 2019 [report to the Education and Skills Committee](#) on STEM in early years education (The Scottish Parliament, 2019), it was suggested STEM is not embedded in the delivery of the curriculum in the early years. There were a number of reasons suggested for this including that the system does not appear to recognise STEM as being core when set against the emphasis on literacy, numeracy and health and well-being. It was also highlighted that inspection frameworks (How good is our early learning and childcare) further compound this issue by using words such as “curiosity”, “imagination” and “creativity” but not necessarily explicitly linking those words to STEM. To attempt to overcome these issues, the committee recommended that a sufficient emphasis was placed on interdisciplinary learning in early education.

Furthermore, a number of submissions to the inquiry highlighted a lack of confidence in pursuing STEM focused activities with children in early learning and primary school settings. Initial teacher education, professional learning provision and the unique challenges faced by early years practitioners (for example, the often high-level of staff turnover experienced, the reduction in the number of teachers in the sector and the distinct training routes followed by staff) were discussed. There are also barriers to teachers and early years practitioners being available to spend time sharing knowledge.

Despite this report being six-years old, anecdotal evidence tells us the issues facing the sector remain similar. Guidance and professional learning have attempted to mitigate some of these issues. One of these is the national practice guidance ‘Realising the Ambition: Being Me’. It states, ‘Creativity is crucial within science, technology, engineering and mathematical learning (STEM)’. Realising the ambition also highlights the importance of outdoor learning and links to the Play Scotland – [Out to Play guidance](#) (Scottish Government, 2018). This guidance outlines how the outdoors provides many opportunities to improve literacy, numeracy and support STEM learning. Enjoying and learning about using their green space responsibly and safely, caring for animals and plants, experiencing seasonal change all help to encourage a connection to the way their world works. These experiences can help provide the foundations for scientific thinking and curiosity. Beginning to appreciate, care and love the outdoors inspires children to care for the environment.

Another attempt to mitigate the issues is a [STEM professional learning module developed by the University of the West of Scotland](#). Designed to inspire confidence, develop new ideas and to instil a fresh outlook on early learning in STEM, the module aims to support practitioners to develop skills, knowledge and confidence in delivering learning in STEM subjects in the Early Years. It is also accredited in order to contribute to the Scottish Social Services Council (SSSC) professional learning requirements. Lastly, the STEM Nation Award programme (see [section 4.2.3](#)) aims to provide support, structure and a forum for sharing practice for early learning and childcare settings.

5.4.2 Pupil voice

The following reports, taken together, highlight that a lot of the topics emphasised by children and young people have strong links with the sciences. The views and ideas shared therefore should be an important consideration for the Sciences Curriculum Improvement Cycle.

[All Learners in Scotland Matter: The National Discussion on Education](#) (Scottish Government, 2023g)

Learners expressed that issues of climate change and global warming were of importance to them. There was a great deal of passion from the children and young people involved about

saving the planet, climate change, and upholding their rights. There were also fears and anxieties, from them, about living in a world that is dramatically changing and evolving.

[Young People and the Future of Scotland: A Participatory Horizon Scanning Engagement](#) (Scottish Government, 2025)

The Horizon scanning project engaged children and young people via a series of workshops. They looked at trends in topics like jobs, health, climate and politics, and discussed what these could mean for Scotland. At the workshops young people discussed five big topics:

- *Climate and environment* – young people urge Scotland to lead on nature protection and green job creation, calling for solutions that address the root causes of climate change and warning that inaction will disproportionately harm vulnerable communities.
- *Economy and jobs* – they want a fair economy with affordable living costs, a just tax system, and broader access to green industries and emerging tech roles, balancing both concern over current inequalities and hope for future opportunities.
- *Politics and government* – they want inclusive, transparent decision-making and strong public services (healthcare, education, transport), while fearing their voices are ignored, misinformation spreads online, and global crises could destabilise Scotland.
- *Society and communities* – they envision an equitable, respectful society with education tied to real-life skills, faster progress on gender equality, and a healthier balance between online and offline engagement to foster collaboration rather than conflict.
- *Health and habits* – they call for enhanced NHS and school-based mental health support with reduced stigma, improved vaping and drug education, and recognition of digital life's impact on sleep, social connection, and loneliness.

[“This is our lives, it matters a lot”. Putting children’s rights at the heart of education](#) (Children and Young People’s Commissioner Scotland, 2025)

The report states that the Curriculum Improvement Cycle must learn from the insights of children and young people, including those who are furthest from enjoying their rights, to build curriculum experiences and opportunities which fulfil children’s rights. Desired outcomes include to:

- have skills and knowledge that is relevant to the world they live in via a varied curriculum
- experience more active and outdoor learning
- have greater access to art and drama and more sports clubs
- learn about their rights, have opportunities for play and rest, as well as time to reflect and study during the school day
- have choices about what they study and be able to follow their interests and develop a pathway of their own
- learn practical skills for life

Curriculum design and implementation must deliver education that develops every child's personality, talents and mental and physical abilities to their fullest potential including personalisation and support for those that need it.

[Children’s Parliament Investigates: Learning for Sustainability](#) (Children’s Parliament, 2022)

Children's Parliament engaged 132 students across five Scottish settings to gather their views on human rights and a Learning for Sustainability curriculum, revealing deep climate anxieties alongside hopeful, solution-oriented ideas. The children called for year-round outdoor learning in every subject, climate change education that involves both adults and young people, and genuine global citizenship links through international school partnerships and youth-led climate action. They stressed that a meaningful Learning for Sustainability curriculum must be consistently implemented, well-resourced, accessible to all ages, and genuinely shaped by children's voices to foster engaging learning, wellbeing, and respect for their rights. Children and adults should have opportunities to work together on these issues.

Children have the right to experience a curriculum that reflects their needs, interests and opinions.

Structural Barriers to STEM – Chapter 4 – The learner voice (Ekosgen, 2022)

This chapter sets out the findings from engagement with learners through the online learners' survey, as well as learner-focused findings from across consultations with STEM leads and teachers. The sample tried to be as widely representative as possible and included children from minority ethnic groups, gender balance, children with a disability, care experienced children and young carers. Findings are summarised below.

- Science is learners' top STEM choice – 36% rank it first and 24% second – and active, enthusiastic teachers are cited as critical to keeping all age groups engaged.
- Pupils want their STEM learning grounded in real-world contexts, with more hands-on activities (32%), STEM challenges (26%), and direct industry links or workplace experiences (31%), alongside diverse, ability-inclusive pathways.
- Most students intend to continue STEM study (driven by interest 52%, future study 46%, career prospects 42%), but disengagement peaks in S1–S3 where 48% of dropouts cite boredom or lack of enjoyment coupled with perceptions of science as 'geeky' – highlighting a crucial intervention point.
- Tailoring pathways to all abilities and ensuring parity of pathways (not just the Higher route), is seen as important. Some 11% of learners reported 'no provision of work-based STEM learning' as a barrier. This would help overcome issues of (perceived and actual) difficulty, and confidence in STEM learning.
- Confidence in STEM is generally high (73% feel "okay" or "good," with males reporting higher confidence), and decisions to continue STEM are most influenced by teachers and parents, with peers having the least impact.

There is agreement between all sources that the curriculum (and related resources) should integrate rights and understanding and respecting all forms of diversity and equality. For example, understanding and appreciation of race, gender, sexual orientation, disabilities, poverty, and other protected characteristics as well as an anti-racist curriculum that acknowledges Scotland's part in slave trade and colonisation.

6 Academic research

This section outlines brief abstracts and commentary to key academic research. A list of research sources was compiled by the Education Scotland Sciences Team in collaboration with the Education Scotland Data, Performance & Research Team and the Scottish Government Library Support Service. More weighting is given to high-quality evidence and data focussing on the Scottish context in the first instance, where it exists. However, a selection of significant and robust research from other contexts is also referenced where this provides insights to our context in Scotland. This is not an exhaustive list.

Initially, a rapid research review was undertaken by Education Scotland's Data Performance and Research Team which is published in a separate document. The full list of research sources can be found in the separately published rapid research review.

In addition, the educational research database EBSCO was searched using the following terms deemed relevant to science education:

- science curriculum
- science learning, teaching and assessment
- science and pedagogy
- nature of science
- science capital
- science identity
- embodied cognition / embodied learning
- science and disciplinary literacy
- science and futures thinking
- science and STEM

The search was initially limited to research that took place between 2010 and 2024. However, to access a greater volume of material, this was broadened to include papers from any period. Research situated in several nations, including Scotland and, England, as well as international meta studies, was reviewed as part of this process. Consideration was also given to grey literature⁶ such as national policy documents, reports and blogs.

Research referred to throughout this section of the paper can be found in the reference list. Papers have mainly been drawn from the search outlined above but further papers have been included that are aligned to the current work of Education Scotland in the area of science. The information retrieved has been organised into themes commonly arising from the research.

6.1 The history and nature of science

The history and nature of science (HNOS) is a phrase used in science education that encompasses issues such as what science is, how science works, characteristics of scientists, and how scientific knowledge is developed and comes to be accepted by the scientific community. Research shows that science is not just a collection of facts or methods but a dynamic interplay of knowledge production and social practices. Understanding these dimensions is crucial as it

⁶ Grey literature is “material that is not produced by commercial publishers. It is produced by governments, local authorities, health boards, research groups, professional associations, charities, not-for profit organisations, companies etc. It may not be indexed in bibliographic databases and this can make it hard to find” (University of Strathclyde, n.d.)

helps students appreciate the complexity and relevance of scientific inquiry in society. The focus on nature of science in science curriculum standards in the last two decades is evident, as shown by a comparative study of eight curriculum standards that included four from the USA and four from Australia, Canada, England/Wales and New Zealand (McComas & Olson, 1998). Recent policy documents in other parts of the world show a similar tendency for including nature of science in varying levels of detail as in the case of Ireland (Erduran & Dagher, 2014).

One of the key motivations for incorporating the nature of science approaches is to help prevent an absolute and static image of science as an established body of knowledge and instead portraying it as a dynamic, tentative, social and cultural human activity (Park and Brock 2023). Developing students' understanding of the nature of science (NOS) is also seen as critical for educating scientifically literate citizens, and has emerged as an important curricular goal internationally (Kostøl et al, 2023; Learned Societies' Group on Scottish STEM Education, 2024).

Furthermore, this approach can help learners distinguish between science and pseudoscience i.e. between reliable and non-reliable scientific claims, particularly pertinent where there is an increasing reliance on acquiring knowledge via social media platforms (Höttecke and Allchin, 2020). Coupled with unreliable sources of information is the evidence that people tend to selectively interpret and accept evidence in ways that allow them to maintain their existing beliefs (Corner et al., 2012). This cognitive bias suggests that care needs to be taken when developing pedagogical approaches to changing beliefs (for example fake news) and that professional learning is a key part of this approach, to provide teachers with more informed ways of addressing the nature of science (Dagher and Erduran, 2016). Finally, incorporating nature of science can help to ensure that critical analysis of information is a core skill. This will allow learners to articulate differences between scientific data and the validity of non-scientific data.

6.2 Sciences and futures thinking

Key to futures thinking and skills are the ability to respond to the need for regeneration, uncertainty and a fast pace of change. A research report by FEDORA (2023) (Future-oriented Science EDucation to enhance Responsibility and engagement in the society of Acceleration and uncertainty) outlines ten recommendations to stimulate futures thinking in a science classroom:

1. Increase awareness of constant change
2. Address uncertainty and ambiguity
3. Reflect on time (future, past and present)
4. Stimulate long-term thinking
5. Apply systems thinking
6. Think in plural
7. Be curious
8. Unlock imagination
9. Make conscious choices
10. Create engaging narratives

This aligns with the Learned Societies' Group on Scottish STEM Education (2024) which posits that embedding ethical literacy into the curriculum can help with the ability to discuss the most important issues of our time – from climate change to poverty to geopolitical instability. Finally, teaching approaches are often historically oriented and there is an identified need to support young people to construct visions of the future that empower actions in the present.

McKinsey (2021) suggests governments could consider reviewing and updating curricula to focus more strongly on the distinct elements of talent (DELTAs) (note: these are a mix of skills and attitudes predicted to be needed in the future world).

56 DELTAS ¹ across 13 skill groups and four categories			
Cognitive		Interpersonal	
Critical thinking ● Structured problem solving ● Logical reasoning ● Understanding biases ● Seeking relevant information	Planning and ways of working ● Work-plan development ● Time management and prioritization ● Agile thinking	Mobilizing systems ● Role modeling ● Win-win negotiations ● Crafting an inspiring vision ● Organizational awareness	Developing relationships ● Empathy ● Inspiring trust ● Humility ● Sociability
Communication ● Storytelling and public speaking ● Asking the right questions ● Synthesizing messages ● Active listening	Mental flexibility ● Creativity and imagination ● Translating knowledge to different contexts ● Adopting a different perspective ● Adaptability ● Ability to learn	Teamwork effectiveness ● Fostering inclusiveness ● Motivating different personalities ● Resolving conflicts ● Collaboration ● Coaching ● Empowering	
Self-leadership		Digital	
Self-awareness and self-management ● Understanding own emotions and triggers ● Self-control and regulation ● Understanding own strengths ● Integrity ● Self-motivation and wellness ● Self-confidence		Digital fluency and citizenship ● Digital literacy ● Digital learning ● Digital collaboration ● Digital ethics	
Entrepreneurship ● Courage and risk-taking ● Driving change and innovation ● Energy, passion, and optimism ● Breaking orthodoxies		Software use and development ● Programming literacy ● Data analysis and statistics ● Computational and algorithmic thinking	
Goals achievement ● Ownership and decisiveness ● Achievement orientation ● Grit and persistence ● Coping with uncertainty ● Self-development		Understanding digital systems ● Data literacy ● Smart systems ● Cybersecurity literacy ● Tech translation and enablement	

Figure 25 - A mix of skills and attitudes predicted to be required in the future (known as distinct elements of talent (DELTAs) (McKinsey, 2021)

Linked to a fast pace of change is the rise of artificial intelligence (AI). Not only has AI been identified as a children’s rights issue (Aitken et al., 2024) but it is also something children need to learn about to help them in their future: to make informed choices and make the most of the opportunities AI affords (Children’s Parliament, 2024). Research from Picton and Clark (2024) for the National Literacy Trust shows that it is clear that many young people are not employing critical practices when interacting with generative AI. AI can also bring significant benefits to educators (World Economic Forum, 2022) and the use of AI should be a consideration in the ‘how’ of Curriculum Improvement Cycle for the sciences including teacher admin, approaches to assessment and personalised learning content.

6.3 Pedagogy in sciences education

Research from the Education Endowment Foundation (2022; 2023), Hattie (2009), McGill et al (2024), Shayer and Adey (1992a&b, 1993), Adey and Shayer (1990, 1993) and Adey (2004) shows that some of the most appropriate pedagogies for teaching science include cognitive acceleration, context-based approaches, direct interactive instruction and inquiry-based pedagogy. The frequency of use of the different pedagogies varies by sector but it is deemed that a mixture is important. Project-based learning is another approach commonly utilised within science education. However, this tends to be used once some knowledge acquisition has already taken place. An area of emerging research around pedagogical approaches also suggests that embodied learning and embodied cognition are important in aiding learner understanding of

STEM based subjects for younger children (Manches and Mitchell, 2023). Lastly, in order to access, understand and accurately use scientific vocabulary, pedagogical approaches to disciplinary literacy are highlighted.

- ***Cognitive acceleration and metacognition***

Cognitive acceleration, grounded in the cognitive psychology of Piaget and Vygotsky, employs structured metacognitive interventions – exemplified by the Cognitive Acceleration in Science Education (CASE) / [Let's Think Science](#) programme – to propel students into formal operational thinking, yielding substantial gains in cognitive development and academic achievement (effect sizes 0.44–0.96) (University College London, 2014; Shayer and Adey, 1992a&b; 1993; Adey and Shayer, 1990; 1993; Adey, 2004). This body of research highlights the necessity of embedding metacognition in teacher professional learning and sequencing curriculum from concrete to abstract concepts – avoiding both under- and over-challenging learners – to sustain engagement and cognitive growth (Shayer, 2003).

- ***Context-based approaches***

These pedagogies motivate students by linking scientific concepts to real-life situations, demonstrating the relevance of science in daily contexts. This can enhance students' attitudes towards science and reduce gender differences in engagement.

- ***Direct interactive instruction***

Direct interactive instruction plays a crucial role in science education by helping students understand science-specific vocabulary and concepts. Approaches enhance students' ability to engage with scientific content, facilitating deeper comprehension and retention. Additionally, direct interactive instruction provides structured opportunities for practice, discussion, and reflection, which are essential for developing the knowledge and skills required to work scientifically. Overall, it supports a more coherent understanding of scientific ideas and improves students' inquiry skills. (McGill et al., 2024). It also involves teaching scientific words and their meanings, which enables students to grasp the nuances of language used in scientific contexts, as many everyday words have different meanings in science. The approach is summarised in the diagram below.

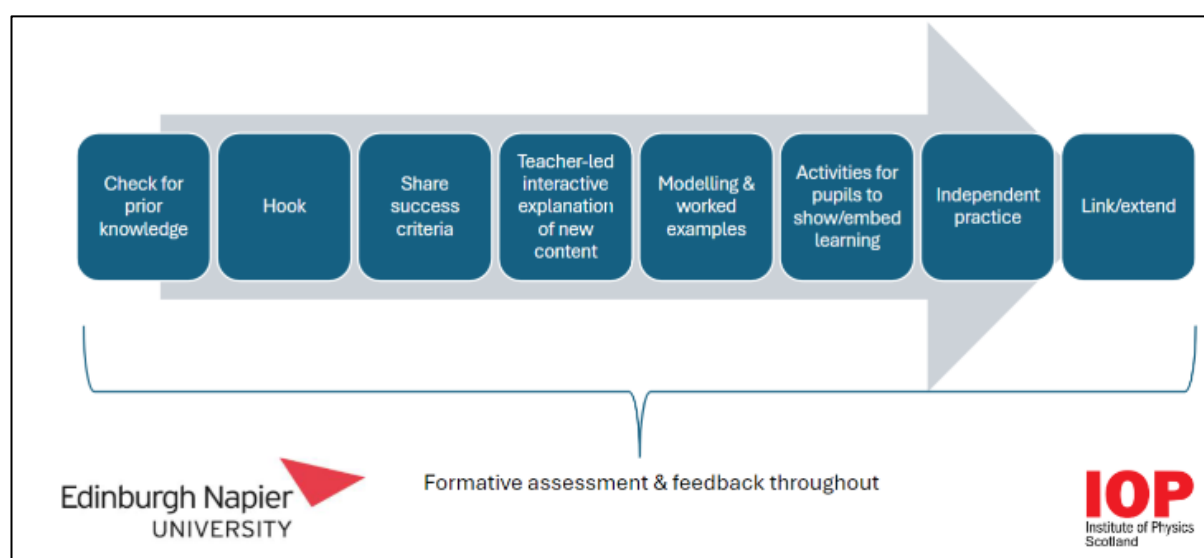


Figure 26 - Elements of direct interactive instruction (McGill & Farmer, 2025)

- ***Embodied learning***

Embodied learning (grounded in embodied cognition) for early and primary science is an approach whereby particular attention is paid to the gestures either practitioners or learners make to demonstrate or aid scientific understanding, as demonstrated by the international Move2Learn project (2017–2020) in informal science centres in collaboration with SSERC (Manches & Mitchell, 2023). Findings highlight that attending to body-based modes of communication can particularly benefit children who struggle to verbalise their thinking and reveal the ongoing challenge of linking sensorimotor experiences to conceptual understanding, underscoring the need for further classroom-based research (Manches & Mitchell, 2023). Key implications for practice from this initial study are summarised as follows:

Key implication	Practice notes
Recognise children's understanding in ways beyond words, especially gestures	Encourage children to express their knowledge in diverse ways
	Encourage gesture, perhaps asking children to 'show' you what they mean
	Continue dialogue by building upon meaning that children communicate through gesture
	Encourage children to reflect and discuss each other's meaning through gesture
Encourage meaningful sensory and movement experiences	Encourage where possible opportunities to gain sensory and movement experiences that are meaningful for science ideas from the everyday environment (e.g. nature trips/tables)
	Use/design materials/activities that provide sensory and movement experiences that are meaningful for science ideas
	Consider how materials may encourage different embodied metaphors for science concepts
Communicate in ways beyond words, especially gestures	Use multimodal communication as children interact to draw children's attention to meaningful actions (and results of these actions)
	Use gestures as children interact to help represent the scientific meaning in their actions
	Use gestures to help children draw upon previous experiences and to represent these experiences more abstractly
	Use gestures to help emphasise key words (beat gestures) and draw children's attention to key information (deictic/pointing gestures)

Figure 27 - Key implications for practice around embodied learning (Manches & Mitchell, 2023)

- Inquiry-based pedagogy***
 This approach emphasises learning through the active participation of students, where they develop understanding by engaging in collecting, analysing, and interpreting evidence. It encourages a constructivist view of learning and mirrors the practices of scientists, fostering deeper comprehension of scientific concepts.
- Project-based learning***
 Supports learning in science by providing hands-on, real-world applications that engage students and bridge the gap between classroom instruction and practical experience. It encourages pupils to take ownership of their learning through self-directed projects, which can enhance their understanding of science concepts, improve attitudes towards science careers, and develop essential skills. Additionally, project-based learning often involves

interdisciplinary approaches and collaborative activities that can help to stimulate greater enthusiasm and retention of interest in STEM subjects. Engaging in such projects outside of the classroom can further help in reinforcing the concepts learned during formal lessons (Education Endowment Foundation, 2022; Ekosgen, 2024).

- *Disciplinary literacy*

Based on the idea that ‘each subject has its own unique language, ways of knowing, doing, and communicating.’ It describes an approach to improving literacy across the curriculum whereby all teachers are supported to understand how to teach students to read, write, and communicate effectively in their subject (Education Endowment Foundation, 2022; 2023). Many researchers posit that generic literacy competencies are not enough; students need instruction specific to the ways of knowing and thinking in science to access and compose texts. In inclusive science classrooms, literacy develops along a continuum of foundational to disciplinary (Shanahan & Shanahan, 2008) and needs to be taught as such, with equal attention to both fundamental and derived aspects of scientific literacy (Drew & Thomas, 2018; Norris & Phillips, 2003).

6.4 Science identity

As outlined in [Section 2.3](#), the uptake of science and STEM subjects varies depending on a number of characteristics. The reasons for this are nuanced but there is a large amount of research exploring this. Science identity is one of the influencing factors. While categorisations of race, class, and gender may influence individuals’ self-perceptions, a concept known as ‘Science identity’ suggests the activities individuals engage in may also be influential. Science identity is broadly defined as: the perception of oneself as well as recognition by others as a science person (Carlone & Johnson, 2007).

According to Archer et al. (2014), several factors can impact science identity and engagement with science. These include:

- science capital-related inequalities
- social inequalities
- educational factors and practices
- dominant representations of science
- personal experiences

Learners who fall into the above categories may therefore need extra support to access and maintain uptake in sciences (for example the ‘[Science capital teaching approach](#)’ (Archer et al., 2014). Research also suggests that active efforts to dispel stereotypes – through representation, targeted interventions, role models, peer influencers, and open discussions help create an inclusive STEM culture. In addition, diverse, interdisciplinary pathways and leadership opportunities for students as well as new teachers can further support. In parallel, hands-on practical learning in well-equipped, mixed-gender spaces involving real-world challenge and project-based activities (especially in S1–S3) can help ensure STEM stays relevant and inspires participation. Active involvement of teachers, careers advisors, parents, and external partners is also of importance (University College London, 2022; Ekosgen, 2024; Golden et al., 2025).

Furthermore, a decolonial sciences curriculum, rooted in the intercultural History of Science model and advocated by Gandolfi (2021) and Muldoon (2019), makes visible the “hidden trajectories” of scientific and technological knowledge. Doing so helps to highlight unequal intercultural exchanges, challenge power relations, and enrich existing frameworks with diverse

examples (for example through the ‘Mirrors and Windows’ approach) (Bishop, 1990). This approach urges educators to confront underrepresentation of protected groups, reclaim non-Western scientific contributions, expose past abuses such as pseudo-scientific racism and unethical experimentation, and address enduring racial biases to foster a more inclusive and critically engaged STEM pedagogy.

Overall, science identity can be a significant influencer of the sense of belonging and perceptions of science that a learner has. These are important factors to consider when designing a new sciences curriculum to try and make it as inclusive and engaging for as diverse a group of learners as possible.

6.5 Improving primary and secondary science

The Education Endowment foundation published two guidance reports:

- [Improving Primary Science](#) (2023)
- [Improving Secondary Science](#) (2018 / 2022)

The reports provide practical recommendations, underpinned by high quality evidence, about how to make meaningful improvements to primary and secondary science teaching. It is designed to help practitioners build on their existing expertise with a view to supporting them to close the attainment gap and cultivate positive pupil attitudes towards science.

The primary report makes six recommendations. These are expanded on in the full report providing details of why it's important and how to implement.

1. Develop pupils' scientific vocabulary.
2. Encourage pupils to explain their thinking, whether verbally or in written form.
3. Guide pupils to work scientifically.
4. Relate new learning to relevant, real-world contexts.
5. Use assessment to support learning and responsive teaching.
6. Strengthen science teaching through effective professional development, as part of an implementation process.

The secondary report makes seven recommendations. Similarly, these are expanded on in the report by citing the evidence, detailing how to implement and signposting to further resources.

1. *Preconceptions* – build on the ideas that pupils bring to lessons.
2. *Self-regulation* – help pupils direct their own learning.
3. *Modelling* – use models to support understanding.
4. *Memory* – support pupils to retain and retrieve knowledge.
5. *Practical work* – use practical work purposefully and as part of a learning sequence.
6. *Language of science* – develop scientific vocabulary and support pupils to read and write about science.
7. *Feedback* – use structured feedback to move on pupils' thinking.

These recommendations will be useful when it comes to considering the focus on disciplinary literacy in the sciences curriculum as well as informing the curriculum implementation documentation.

7 Future trends

This section aims to use evidence and predictions available to outline future global trends, relating these to the likely impact on Scotland and its education system. Given that one of the aims of the Curriculum Improvement Cycle is to co-create a future-oriented curriculum, the trends in this section, whilst not certain, offer some insights for consideration.

Some of the challenges facing the world, common to many future looking reports and analyses include:

- rising global conflict (PWC, 2024; Scottish Government, 2025; OECD, 2025a)
- climate change, biodiversity loss and reduced food security (Patton et al., 2016; Royal Society of Edinburgh, 2024; PWC, 2024; Scottish Government, 2025; OECD 2025a&b)
- rise in mental health concerns and obesity (especially in young people) (Patton et al., 2016; OECD, 2025a; PWC, 2024; Scottish Government, 2025)
- aging populations (Scottish Government, 2025; PWC, 2024)
- technological disruption and polarisation via increased use of AI and emerging technologies (Royal Society of Edinburgh, 2024; PWC, 2024; Scottish Government, 2025; OECD 2025a;
- widening inequalities (including concentration of wealth, social instability and health inequalities) (Patton et al., 2016; PWC, 2024; Scottish Government 2025; OECD, 2020; OECD 2025a)
- rising costs of living (World Economic Foundation, 2025)

It is also important to note that trends identified are likely to affect children and young people differently, or disproportionately, compared with impacts for older generations. This is, in part, because children and young people have to live with the outcomes of identified trends for longer, and the long-term future has particular importance for those who are youngest now (Scottish Government, 2025). They are increasingly exposed to conflict, displacement, environmental degradation, and unregulated commercial exploitation, especially in digital and food environments as well as being the first generation to grow up under the 'shadow of climate change' (Patton et al., 2016).

Young people may also experience societal transformations differently from older generations because they are often at the leading edge of change or technology adoption. The trends will also have differential impacts for different equalities groups. Intersecting inequalities and disadvantage may reduce resilience or the ability of both households and communities to adapt to future challenges, or to take advantage of future opportunities. In many cases the trends have the potential to drive and deepen inequalities still further (Scottish Government, 2025).

Despite these challenges, there are also opportunities for a future-oriented curriculum:

- *Curriculum flexibility and personalisation* – a modern curriculum that is fit for purpose, meets individual aspirations and delivers a just society that meets climate goals and achieves strong economic future (OECD, 2020; Royal Society of Edinburgh, 2024).

- *Learner agency and co-agency* – ownership of their learning and being able to navigate uncertainty (OECD, 2020; Patton et al., 2016).
- Empowerment – education is positioned as a key driver for enabling individuals and communities to understand environmental challenges and take informed, responsible action (OECD, 2025b)
- *Bodies and minds* – the need for socio-emotional learning, digital wellbeing, and health literacy across all age groups (OECD 2025a; Patton et al., 2016).
- *Transformative competencies* – go beyond subject knowledge to include attitudes, ethics, and values allowing learners to create new value, reconcile tensions and dilemmas, and take responsibility (OECD, 2020).
- *Critical skills* – skills such as AI and big data; analytical thinking; creative thinking; resilience, flexibility and agility; and technological literacy are not only considered critical now but are also projected to become even more important (World Economic Forum, 2025; OECD, 2020) as well as green skills (OECD, 2025b).
- *Continued relevance of human-centric skills amid rapid technological advances* – leadership and social influence, curiosity and lifelong learning, systems thinking, talent management, and motivation and self-awareness considered important for this (World Economic Forum, 2025).
- *Equity and inclusion* – curriculum design must address widening inequalities (for example via intercultural understanding) and ensure access to meaningful learning for all, regardless of background or circumstance (OECD, 2020; OECD, 2025a).
- *Broader educational goals* – education should promote individual and collective wellbeing, sustainability, and social cohesion – not just academic achievement or economic productivity. Therefore, encouraging society to value all educational pathways and destinations (OECD, 2020; Royal Society of Edinburgh, 2024).

These trends reflect a global shift toward education systems that are necessarily more adaptive, inclusive, and future-oriented principles that align closely with Scotland's Curriculum Improvement Cycle. They encourage co-creation and learner agency as well as reflecting learners' lived realities while preparing them for emerging challenges.

8 Points to consider

This section seeks to identify some of the main points arising from the evidence cited in the paper which should be considered through the Curriculum Improvement Cycle (CIC) process. It is hoped that this section highlights the main points the CIC stakeholder groups should be considering when co-creating and giving shape to the evolved curriculum for sciences. The CIC process itself should be drawing the conclusions. Considerations are as follows:

- The high number of policies and strategies linked to sustainability, climate change, nature and biodiversity demonstrate that the sciences curriculum has a significant part to play in nurturing citizens who care and respond to these challenges.
- Labour market information shows that health care, construction and social care are predicted to be the highest employing industries in Scotland in 2034. Other economic sectors include green jobs, engineering, energy, food and drink, space, advanced manufacturing, nature and land-based jobs, and life and chemical sciences. The sciences curriculum has a critical role to play in meeting these employment requirements. The Curriculum Improvement Cycle should consider this when reviewing the content and structure of each curricular area and particularly in reference to skills.
- There is a range of qualifications delivered by secondary science departments and over the last few years, uptake of non-examined qualifications have shown an upwards trend. Further work may be required to raise awareness about pathways with schools, settings, learners and parents and families. The breadth and nature of qualifications on offer for the sciences should be considered as part of the CIC process.
- With some exceptions, pass rates in SQA sciences National Qualifications in 2024 are lower than 2019 levels, especially at Advanced Higher levels. SQA 2024 course reports highlighted literacy levels and a lack of practical knowledge, as areas for improvement across the sciences. In addition, some sciences qualifications highlighted application of knowledge to unfamiliar contexts as an area for improvement.
- The PISA (2022) study also shows an overall decline in average scores for science in Scotland since 2006, reflecting decreases in performance globally. There are a number of possible reasons for this which include, amongst others: literacy proficiency in answering questions; the lack of familiarity of completing online assessments; the disconnect between the topics in the PISA assessment and the content covered in the sciences curriculum in Scotland at this age.
- International reports and frameworks further highlight the need for scientific understanding and science as the producer of reliable knowledge in the 21st century when humanity faces an uncertain future. They outline competencies, knowledge types and science identity measures that will help work towards scientific understanding and shown to be significant for science education. This will help support thinking around the big ideas and conceptual knowledge for sciences.
- In relation to evidence from HMIE inspections, Quality Indicator 2.2 *Curriculum* is not considered to be a core quality indicator and, as a result, there is limited evidence gathered by HMIE inspection teams about practice in science and STEM learning. However, the limited evidence available would suggest that the sciences and maths

curriculum can be better integrated to provide children and young people with engaging lesson content, applications in new and real-life contexts. Scientific language development and communication skills will also be key to this.

- Education Scotland and Ekosgen reports offer insight into the structural barriers to STEM engagement, as well as factors in successful STEM engagement. These include: current curriculum requirements restrict the ability to develop and deliver innovative STEM content leading to a siloed approach, qualification pathways need to be expanded (by introducing innovative qualifications that provide broader and more inclusive access to STEM learning and careers), STEM visibility should be boosted via real-world examples and flexible teaching methods such as IDL and project-based learning (particularly during the broad general education). IDL support should also increase and the STEM landscape should be streamlined.
- Practitioners (ELC, ASN, primary and secondary) would like more professional learning around:
 - pedagogies and teaching approaches to deliver STEM learning effectively
 - skills progression in STEM subjects
 - developing the curriculum for STEM
 - barriers to learning

Technicians (otherwise missing from the evidence base) would like more professional learning on:

- health and safety updates
- sciences
- skills progression in STEM subjects
- Science education has a large number of partner organisation and stakeholders, all of whom contribute positively to the science educational experience. Impact evidence shows they improve the confidence and communication skills of learners, help to embed creative thinking applied to real life, develop valuable attributes for life, learning and future careers, enhance leadership skills, raise awareness of careers and improve learner interest in and enthusiasm for science and STEM. Provision of these and learning from them is an important consideration offering alternative ways of assessing and engaging learners. For example, outdoor learning needs to be a planned and integral part of the sciences curriculum.
- Learned Societies recommend a big ideas approach with similarities in the core purposes of science education:
 - knowledge and understanding of the world and how it works
 - development of practical skills and scientific process and the influence these have on the world and society
 - how do scientists do science: the practices and ways of thinking of science
- The annual RSC Science Teaching Survey highlights a decline in technician numbers with many teachers listing the understaffing of technicians as detrimental to student outcomes. Insufficient school funding was also highlight as a barrier.
- In STEM education in early years, there was a lack of confidence in teaching STEM, and challenges in viewing STEM as core to educational experiences (when in competition with literacy, numeracy and health and wellbeing). Words such as curiosity and creativity

in the 'How good is our early learning and childcare' framework could be more explicitly related to STEM. *Realising the ambition* also highlights outdoor learning as a natural place for STEM learning.

- Learners are calling for a curriculum that focuses on climate change, looking after the planet, outdoor learning, equalities, health and wellbeing and having their rights upheld, all of which are closely linked to Learning for Sustainability. For STEM specifically, learners report that they want their learning experience rooted in the real world (topics that are relatable for them), more applied learning, learning in context. Both learners and parents would like more opportunities to engage with businesses and visit live workplaces or take more work placements/experience accompanied by more information on STEM jobs.
- Considerations from academic research include:
 - Acknowledging the nature of science as dynamic, situated in context and influenced by narrow historical representations of science.
 - Science and futures thinking – dealing with uncertainty and ambiguity as well as developing critical thinking skills are important for futures thinking and coping with future global megatrends.
 - A range of pedagogies appropriate to sciences learning and teaching (cognitive acceleration, context-based learning, direct interactive instruction, embodied learning, inquiry-based learning, project-based learning) should be considered alongside cognitive development concepts. Accessing, understanding and successfully using scientific terminology is necessary therefore pedagogies associated with disciplinary literacy (as opposed to generic literacy skills) should be considered.
 - Science identity is complex and often intertwined with societal representations of science, as well as race, class and gender. The activities individuals engage in may also be influential. It is important to consider how barriers can be removed for learners who have a reduced science identity.
- Future trends highlighted there are a range of challenges facing society from rising global conflict to climate change and biodiversity loss; rises in mental health and other health concerns to technological disruption as well as widening inequalities. All are likely to affect children and young people disproportionately now and in the future. A future-oriented education system should consider opportunities to tackle these challenges such as:
 - curriculum flexibility and personalisation
 - learner agency and empowerment
 - the need for socio-emotional learning, digital wellbeing and health literacy and social cohesion
 - transformative competencies that go beyond subject knowledge
 - development of human-centric skills
 - addressing widening inequalities through equity and inclusion
 - value collective wellbeing, sustainability and social cohesion not just academic achievement or economic productivity
- Future trends of particular relevance to science and STEM education include:
 - democracy, polarisation, and misinformation
 - living standards and income inequality
 - labour market and skills

- poverty and wealth
- AI and emerging technologies
- green technologies and life sciences
- cyber security
- climate change and just transition
- biodiversity and soils
- water and marine ecosystems
- food, agriculture, forestry, land, and waste
- population health and infectious diseases

It is important to note that there is a lack of evidence available for some sectors and practitioners. This includes a lack of evidence around the provision of science in the additional support needs (ASN) sector. For example, the recommendations from the Morgan review (2020) and the recent Audit Scotland (2025) briefing around ASN provision recognise that any review of curriculum must maintain a strong and central focus on the experience of all children, young people, parents and carers and the professionals in closest connection with them. This will ensure visibility for the diverse range of achievements that are possible for all children and young people with additional support needs.

There is also lack of evidence acknowledging the role of and importance of technicians in delivering science education. In addition, whilst there is academic research examining STEM in the early years or at early level, evidence reports on the science and STEM experience at early level and in early learning and childcare settings is otherwise limited and could be highlighted as a gap.

9 Declaration

The content of this document was written by the author, exercising full professional judgement. Education Scotland approved AI tools were used to support review, clarity, and quality assurance. Education Scotland staff retain full responsibility and have reviewed and approved all content.

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Version History

Version	Date	Detail
Version 1	6 March 2026	First published
Version 2	18 May 2026	The section on National Data Sets p8 – p36 has been updated to ensure the language used is consistent with the language used by Qualification Scotland.
		Addition of Declaration on the use of AI.

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