The STEM Research & Innovation Framework

IRIS The Institute for Research in Schools

Please note, the STEM Research and Innovation Framework (R&I Framework) signposts teachers and schools to resources and organisations that can help schools to improve their STEM provision.

We reference a range of organisations that are leading the way in STEM education but their inclusion here does not infer their endorsement of the R&I Framework.

01 Contents

The Institute for Research in Schools

Foreword

When I started my school teaching career, I already had a PhD in science (evolutionary biology and population genetics). Once I had survived my first couple of years in the classroom – getting on top of all the syllabuses, learning the ropes, etc – I started to get some of the keener of my students to do little research projects.

What I now realise, looking back on it, was how fortunate I was in the circumstances in which I found myself:

- I had a wonderfully supportive Head of Department who encouraged me and allowed me to try out some half-baked ideas.
- The A-level biology course had an optional project with a mark scheme that rewarded originality.
- There weren't the pressures then of league tables, and inspection by Ofsted was seen as a positive – an opportunity to get feedback from experts who were on your side.
- Although in the state sector, the school was well-resourced and there was a culture, not just in science, of positivity and creativity.

I doubt nowadays that I would be able to get many of my students to do the sorts of original research that they did unless I had a resource like this wonderful STEM Research and Innovation Framework.

I commend this framework wholeheartedly!

Prof Michael Reiss
Professor of Science Education
UCL

If the UK is to become a science superpower, we must start by inspiring the next generation of scientists while they are at school. To realise this huge ambition, we must capture the untapped talent and remove any barrier that prevents young people from engaging in science. Excellent teaching by teachers who have good subject knowledge is central to this but is not enough by itself.

To truly light the fire of enthusiasm for science in students, a fresh approach is needed. One which allows all children to feel the excitement of discovery, values diversity within the science community and empowers historically excluded groups. We need an established process that makes it easy for school leaders to build science capital for young people, highlight opportunities in science at local and national levels and promote all routes into science including vocational as well as traditional academic pathways. I strongly believe IRIS' STEM Research and Innovation Framework clearly outlines this much needed approach.

The framework supports teachers and school leaders in evaluating their schools' wider STEM provision and critically highlights what actions can be taken to drive improvement. It brings together recommendations about best practice and signposts the organisations which provide the best support. It contains self-assessment tools to identify where your school is and where to go next.

The R&I Framework has been written with teachers and school leaders in mind, taking into account the financial and time pressures that exist in schools. For an approach to work effectively in schools, it must be evidence-based, straightforward to understand and easy to implement. These principles have been central to the development of the framework. I hope you will find it useful in capturing the talent of the young scientists in your school and providing them with life changing opportunities.

IRIS is grateful to the Battcock Charitable Trust for supporting this work.

Dr Jo Foster
Director
The Institute for Research in Schools

04 Introduction

The STEM Research and Innovation Framework (R&I Framework) has been developed to improve the experience that young people in schools have in science, technology, engineering and maths.

IRIS has supported many schools and colleges across the country to transform the experiences and opportunities of young people in STEM. We've seen, first-hand, the benefits of research and innovation to young people, from improved learning and engagement in science to new STEM career aspirations. We believe every student should reap the benefits of research and innovation while at school and this is why we are proud to publish the R&I Framework.

'Research and innovation' is not a new term and is widely used to describe producing new knowledge (research) and using that knowledge to solve problems (innovation). In schools research and innovation can be used to promote STEM, to empower students to discover and apply knowledge to solve problems and to engage students in the true nature of science and research.

Research and innovation can also be a powerful tool to engage under-represented or historically excluded groups in STEM. We must do this to help address the STEM skills gap and reap wider economic benefits for the UK but, more importantly, to facilitate social mobility and 'levelling-up' – it is still the case that STEM jobs are more highly paid than comparable non-STEM jobs.

As experienced school leaders and teachers, at IRIS we understand how challenging running a school can be and how difficult it is for teachers to balance the competing demands on valuable curriculum time. In the best schools, where student experiences are exemplary, students are well supported academically to develop a strong foundation of knowledge. These students experience a wealth of opportunities which fundamentally change their relationship with, and enthusiasm for, STEM. Such experiences include regular encounters with scientists, research partnerships with universities and industry and outstanding careers advice.

The R&I Framework has been developed to highlight many of the most impactful elements of wider STEM education found in leading schools. It brings together best practice and maps it out to provide a guide to schools of actions they can take to improve their STEM provision. It should be used as a reflective tool rather than a check list of actions. While the focus of the R&I Framework is on STEM, the principles behind it can be applied to many other subject areas within a school.

The five themes of the R&I Framework are:

1. Leadership, Vision & Culture
2. Research Opportunities & the Curriculum
3. Careers in Research & Innovation
4. Community & Collaboration
5. Capturing Talent & Removing Barriers

Collaboration is at the heart of the framework. We have engaged with, and sought advice from, a wide range of partners and leading organisations within the STEM and education communities to ensure that this framework is as impactful as possible. Over the next few years, we will be evaluating the R&I Framework and producing supporting resources for teachers and schools. There are many organisations across the UK that provide schools, teachers and students with outstanding support and opportunities in relation to STEM. Those referenced and recommended within the R&I Framework do not represent an inclusive list and we encourage teachers and school leaders to continue to collaborate with organisations that best support them and meet the needs of their local context.

We hope that the R&I Framework will support schools and colleges to engage students in STEM and inspire many of them to take up a career in research and innovation. To achieve this, we want to hear from you. Whether you are a leader or teacher with a desire to develop research within your school, an academic or business interested in supporting the next generation of scientists or a charity with a great idea of how to support research and innovation, we would encourage you to get in touch.

Marcus Bernard
Deputy Director
The Institute for Research in Schools

About IRIS

Background

IRIS was founded on the belief that young people have the capacity to change the world. If their education empowers them with the right tools, school-aged students can contribute to the community of scientific research right now.

Despite the evolution of IRIS over the last few years, this founding belief continues to be central to what we do.

Our mission

IRIS aims to change the culture in UK education so that authentic research and innovation is part of every young person's experience.

We do this by:

- **Creating opportunities** for students to participate in cutting-edge STEM research and collaborate with leading universities and institutions while still at school
- **Evidencing the impact** on students of carrying out research while still at school
- **Facilitating a research culture** by influencing and demonstrating best practice of STEM research and innovation in schools

As a charity, everything we do is driven by our moral purpose; to capture talent and break down barriers that impact underrepresented young people in STEM.

Our impact and reach

- Despite the challenges of COVID-19, throughout 2020 and 2021, we supported **1027 students** to carry out research in school or at home.
- In 2021/2022, we expect to work with 1500 students rising to **2500 students** by 2024.
- Since 2016, we have welcomed over **350 schools and colleges** across the UK as members of IRIS.
- We have collaborated with over **80 universities** and institutions to provide research opportunities to students.
- Over **2200 students, teachers, researchers** and members of the wider STEM community have participated in our conferences since 2018.

97%

of teachers who have led IRIS projects say students were more engaged with science and motivated to learn.

94%

of teachers say student research projects from IRIS help them put learning in context.

77%

of teachers say working with IRIS supports students to build an awareness of STEM and STEM careers.

89%

of students plan to study STEM at university after working on an IRIS project.

77%

of students tell us that taking part in research gives them a better understanding of science.

81%

of students felt that their projects had contributed to scientific research.

The Institute for Research in Schools

08 Rationale

What is STEM, research and innovation, and why is it important?

STEM, Research and Innovation

In education settings and policy, STEM is a term used to describe the disciplines of science, technology, engineering and maths. Historically, STEM programmes and initiatives have focused on developing interdisciplinary skills and providing learning opportunities in real world or problem-solving contexts.

Today, STEM covers a wide variety of subjects and skills all relating to science, technology, engineering and mathematics.

Research and innovation is not a new term and is widely used in academic, industrial and policy settings to describe producing new knowledge (research) and using that knowledge to solve problems, create technologies and improve lives (innovation).

Throughout this document, the term research and innovation refers to activities in schools and colleges which promote STEM. It empowers students to discover and apply knowledge, solve problems and address real-world issues. Research and innovation engages students in the true nature of science and research.

Why is STEM important and what is the problem?

The British Government has an ambitious plan to establish the UK as a 'science superpower', increasing public funding for research and development to £22 billion per year[1]. Central to this ambition is the hope to 'inspire and enable people from all backgrounds and experiences to engage in and contribute to research and innovation and show that science is for everyone'[2]. Two key strategies outlined by the Government to do this are: to improve the culture of research and to grow the research talent pipeline. Almost all policy, strategy and investment in these two crucial areas, however, focus exclusively on tertiary education settings.

A significant driving force behind the Government's ambition has been the global Covid-19 pandemic. It has demonstrated the importance of STEM and the STEM workforce to our prosperity and security here in the United Kingdom. From nurses and doctors to epidemiologists, virologists, chemical engineers and data scientists - the list of STEM workers who have played a vital role throughout the COVID-19 crisis is extensive.

The UK has always been at the forefront of science and technology, from the industrial revolution in the 18th century, to the creation of cutting-edge coronavirus vaccines just a few months ago. Even before the emergence of COVID-19, we were looking to those who work in STEM to help us solve some of the biggest issues humanity has ever faced, including reducing global warming and combating the inevitable effects of climate change. The truth is that science and technology is becoming ever more important in our daily lives - and to the economy.

Since 2003, growth of STEM jobs has outstripped that of non-STEM jobs, a trend which is expected to continue into the future[3]. Whether or not you directly work in STEM, over time an increasing number of roles will require STEM skills as we transition to a high-skilled and green economy.

From 2007 to 2017, government spending on initiatives to encourage the take-up of STEM subjects exceeded £990 million[4]. Although in recent years there has been an increase in the number of young people studying some STEM subjects at university[5], we remain a country with a well-documented STEM skills gap. This gap is estimated to be costing employers £1.5 billion each year[6] with 40% of them continuing to cite a shortage of STEM graduates as a significant issue[7].

In the UK women make up only 24% of the core STEM workforce and while this is expected to reach 29% by 2030[8], it still represents a significant gender imbalance. There is also work to be done to increase the number of individuals from minority ethnic backgrounds working in STEM; black and minority ethnic men are 28% less likely to work in STEM than white men[9].

Rationale
continued

The STEM engagement problem

For many young people in school, there are still significant barriers to engagement in STEM, meaning that their views and attitudes toward these subjects are unlikely to change without a shift in approach from educators. If the UK is truly going to become a global science superpower, and wishes to ensure that science is for everyone, then we must start that journey with young people in our schools and colleges.

While socially advantaged students, particularly boys, are more likely to aspire to work in STEM than their peers[10], many students feel that science is not for them[11] and fail to see its relevance to their lives. Many are also put off from pursuing further study or a career in STEM due to the dominant educational and social representations of science being 'masculine' or reserved for those who are 'clever' or 'science-y'[12].

Science is often seen as being more difficult than other subjects[13], a view that is often reinforced by the tiered qualification system of Double or Triple awards in GCSE Science. Furthermore, the unusually high entry requirements for STEM A-levels, along with the disparity between traditional academic qualifications verses vocational courses, perpetuates a sense of exclusion for many students around STEM.

Although this may all sound disheartening, there is good news. Thanks to cutting-edge research studies such as *ASPIRES*[14] from UCL and *Chemistry for All*[15] from the Royal Society of Chemistry, and the ongoing work being done by organisations such as the British Science Association, the Association of Science Education and STEM Learning, teachers now not only have an evidence-based understanding of engagement issues but also have effective tools and strategies to help them break down barriers and capture talent.

A framework for the future

For young people sitting in our classrooms today, research and innovation may not mean much, but one thing is clear, STEM is going to become ever more important in their lives and will offer them real opportunities in the future.

As educators, it is imperative that we prepare students to take advantage of these opportunities and empower them to become active citizens in a technologically advancing society. As former teachers and school leaders, we understand how challenging teaching and running a school can be, this is why we have developed the R&I Framework - to support you in providing life changing opportunities to students.

Evidence and research considered in rationale

1,2 HM Government. (2020). *UK Research and Development Roadmap.* Available at: www.assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data file/896799/UK_Research_and_Development_ Roadmap.pdf (Accessed 13 January 2022).

3 EMSI. (2018). *Focus on the demand for STEM jobs and skills in Britain.* UK:EMSI. Available at: www.economicmodelling.co.uk/wp-content/uploads/2018/12/STEM-Report_vWEB.pdf (Accessed: 13 January 2022).

4 National Audit Office. (2018). *Delivering STEM (science, technology, engineering and mathematics) skills for the economy.* London: NAO External Relations (DP Ref: 116-2-001) Available at: www.nao.org.uk/wp-content uploads/2018/01/Delivering-STEM-Science-technology-engineering-and-mathematics-skills-for-the-economy.pdf (Accessed: 13 January 2022).

5 The Education Hub. (2021). *More young people are taking STEM subjects than ever before.* Department for Education Education Hub Blog. Available at: www.educationhub.blog.gov.uk/2021/02/09/more-young-people-are-taking-stem-subjects-than-ever-before/ (Accessed: 13 January 2022).

6 STEM Learning. (2018). *Skills shortage costing STEM sector £1.5bn.* Available at: www.stem.org.uk/news-and-views/news/skills-shortage-costing-stem-sector-15bn (Accessed: 13 June 2021).

7 HM Government. (2017). *Industrial strategy: Building a Britain fit for the future.* Available at: www.assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf (Accessed: 13 January 2022).

8 Wise. *(2019). 2019 Workforce Statistics – One Million Women In STEM In The UK.* Available at: www.wisecampaign.org.uk/statistics/2019-workforce-statistics-one-million-women-in-stem-in-the-uk/ (Accessed 13 January 2022)

9 Campaign for Science and Engineering. (2014). *Improving Diversity in STEM.* London: CaSE. Available at: www.sciencecampaign.org.uk/resource/ImprovingDiversityinSTEM2014.html (Accessed: 13 January 2022).

10,12,14 Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). *ASPIRES 2: Young people's science and career aspirations, age 10–19.* London: UCL Institute of Education. Available at: www.discovery.ucl.ac.uk/id/eprint/10092041/6/Moote_9538%20UCL%20Aspires%202%20report%20online%20version.pdf (Accessed 17 January 2022).

11 Jenkins, E. and Nelson, N. (2005). Important but not for me: students' attitudes towards secondary school science in England. *Research in Science and Technological Education,* 23 (1), 41-57.

13 Fouad, N., Hackett, G., Haag, S., Kantamneni, N. and Fitzpatrick, M. E. (2007). *Career choice barriers: environmental influences on women's career choices.* Paper presented at the Annual Meeting of the American Psychological Association Convention, San Francisco, CA, August.

15 Royal Society of Chemistry. (2020). *Chemistry for All: Reducing inequalities in chemistry aspirations and attitudes.* London: Available at: www.rsc.org/new-perspectives/talent/is-chemistry-accessible-for-all/ (Accessed 17 January 2022).

12 Student-led research

The term student-led research, used throughout this document, describes activities that enable young people to experience STEM in the way that researchers do through authentic scientific research.

Such activities usually involve students using scientific methodology to carry out an investigation, for which the answer is unknown to them, over an extended period of time.

In the past, student-led research has been referred to as independent research projects (IRPs) or open-ended and extended investigative projects. These types of projects are one of eight recommendations of the Good Practical Science Guide published by the Gatsby Charitable Foundation. IRPs and similar activities can be seen as challenging for both teachers and students and it is no surprise that in many schools and colleges they are only offered to A-level students. While this is understandable, it is potentially problematic as we now know any interventions to broaden students' STEM aspirations need to start at an earlier age .

At IRIS student-led research also encompasses projects that have a lower degree of openness and a higher degree of structure and support. This is to enable a culture of research and innovation to develop in schools.

Getting started

The British Science Association's CREST Awards can be completed at six levels (www.crestawards.org) including Bronze Awards for students aged 11+, while IRIS offers projects at three levels to support students, teachers and schools on their research journey (www.researchinschools.org).

13 Examples of student-led research from IRIS

IRIS works with the scientific community to develop research projects that suit different ages, abilities and interests. Many of our projects allow students to collaborate in real scientific research, where they learn new knowledge, develop advanced skills and gain insight into today's scientific challenges.

Whether it's the classification of stellar objects or trees, our students' findings often contribute to our partners' own research initiative.

To find out more:
www.researchinschools.org/projects

Big Data: ATLAS

This project introduces students to the ATLAS experiment in an attempt to answer fundamental questions about our Universe, including our understanding of the basic building blocks of matter and the fundamental forces of nature.

Partners
— **University of Oxford**
— **Rutherford Appleton Laboratory**

Carbon Researchers

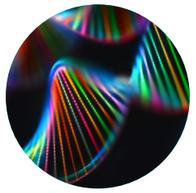
Students calculate their school's carbon footprint and devise a plan to reduce it. This project encouraged a student-led movement on Guernsey which inspired local government and business to improve their environmental impact.

Partners
— **Carbon Footprint**
— **UK Space Agency**

Cosmic Mining

Students examine and classify stellar objects, contributing to the first fully classified catalogue of such data. Their work will assist astronomers with the identification and selection of potential targets for the James Webb Space Telescope.

Partners
— **James Webb Space Telescope UK**
— **Science and Technology Facilities Council**



DNA Origami

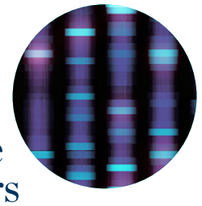
A creative introduction to material science and the exciting world of DNA technology, students learn how to design using DNA as a building material. They work alongside researchers to investigate the potential applications of their design.

Partners
— **Henry Royce Institute**
— **University of Leeds**

Earth Observation

Using satellite data, students measure and research changes in the Earth's landscape, helping scientists evidence the dramatic environmental shifts in places like Antarctica. Work by students at Stirling High School led the British Antarctic Survey to discover a new colony of emperor penguins.

Partners
— **Centre for Polar Observation & Modelling**
— **UK Space Agency**
— **SENSE**



Genome Decoders

Students have contributed more than 20,000 annotations of the genome for the human whipworm, *Trichuris trichiura*. Their work supports a wider research effort to understand this parasitic worm which causes a Neglected Tropical Disease.

Partner
— **Wellcome Sanger Institute**

Research and evidence: what are the benefits of student-led research?

Impact on learning

Research shows that student-led research, such as IRPs, improves students' engagement with their work. It increases their interest, motivation and self-regulation. This type of active and participative learning can also improve students' conceptual understanding and academic performance in science. As well as improving practical skills in science, participating in this kind of research nurtures a range of other skills such as problem solving, planning, teamwork and resilience.

Independent Research Projects may boost GCSE results by half a grade

An independent research study showed that students who took part in the British Science Association's CREST Awards achieved better GCSEs and were more likely to pick STEM A-levels.

Evidence suggests that students who take part in a Silver CREST Award perform half a grade better in GCSE Science.

Check out the study here:
www.bit.ly/IRIS_22

Improved attitudes to science

Participation in real research projects can help to dispel myths around science, giving students a more realistic idea of what researchers do and why science is important. It helps bridge the gap between school science and real science. The emphasis on real problems and practical skills has been found to motivate students to continue with science.

Inspiring future paths

A wealth of data, including our own evaluation work, indicates that participation in student-led research projects increases students' interest in pursuing careers in science. These activities give them a better idea of what working in science is like and the range of opportunities available, opening up a world of possibilities for a future in science.

Improved career awareness

School science is the starting point for many young people to make links between what they are learning and career opportunities in the wider world. Working on student-led research, with input from scientists working on real-world problems, helps students develop an understanding of the range of roles in science careers and the diverse routes to pursuing STEM careers.

Inclusion for the historically excluded

Studies indicate that students from under-represented backgrounds in STEM benefit even more than other students in terms of engagement and achievement in science as a result of their participation in IRPs. An emphasis on practical science has been found to be particularly motivating for disadvantaged and disengaged students.

Benefits to teachers

Student-led research in schools puts teachers back in touch with the scientific research they enjoyed when studying science, boosts their research experience and puts them in touch with new developments in science. They develop networks with scientists and other teachers and, by mentoring the students through their projects, their relationships with their students are enhanced. Good student-teacher relationships and increased access to science-related opportunities for students have been related to science teachers' job satisfaction.

Evidence and research considered

Bennett, J., Dunlop, L., Knox, K. J., Reiss, M. J., & Torrance Jenkins, R. (2018). Practical independent research projects in science: a synthesis and evaluation of the evidence of impact on high school students. *International journal of science education,* 40(14), 1755-1773.

Cilauro, F., Paull, G., & Economics, F. (2019). Evaluation of Nuffield Research Placements: interim report.

Dunlop, L., Knox, K. J., Turkenburg, M. G. W., & Bennett, J. M. (2019). Practical, open-ended and extended investigative projects in science. White Rose University Consortium

Drymiotou, I., Constantinou, C. P., & Avraamidou, L. (2021). Enhancing students' interest in science and understandings of STEM careers: the role of career-based scenarios. *International Journal of Science Education,* 1-20.Dunlop, L., Knox, K. J., Bennett, J. M., Reiss, M., & Torrance Jenkins, R. (2019). Students becoming researchers. *School Science Review,* 85-91

Good Practical Science, Gatsby Foundation, September 2017

Holman, J., Hickman M., Leevers, H. (2016). Young Researchers: Reflections from Wellcome on the impact of doing research projects. Wellcome Trust

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction: what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching,* 47, 474–496.

Moote, J. K., Williams, J. M., & Sproule, J. (2013). When students take control: Investigating the impact of the CREST inquiry-based learning program on self-regulated processes and related motivations in young science students. *Journal of Cognitive Education and Psychology,* 12(2), 178-196.

Rushton, E.A.C & Reiss, M.J. (2019): From science teacher to 'teacher scientist': exploring the experiences of research-active science teachers in the UK, *International Journal of Science Education,* DOI: 10.1080/09500693.2019.1615656

Saunders, M. E., Roger, E., Geary, W. L., Meredith, F., Welbourne, D. J., Bako, A., ... & Kunstler, M. (2018). Citizen science in schools: Engaging students in research on urban habitat for pollinators. *Austral ecology,* 43(6), 635-642.

Song, S., & Mustafa, M. (2015). Factors Impacting on Teachers' Job Satisfaction Related to Science Teaching: A Mixed Methods Study. *Science Education International,* 26(3), 358-375.

Stock Jones, R., Annable, T., Billingham, Z., & MacDonald, C. (2016). Quantifying CREST: What impact does the Silver CREST Award have on science scores and STEM subject selection. *A Pro Bono Economics research report for the British Science Association.*

Young people's views on science education: Science Education Tracker 2019, wave 2. March 2020. Wellcome Trust.

Also: IRIS Internal Evaluation Data

The Framework

Overview

Designed for teachers and school leaders by teachers and school leaders, the STEM Research and Innovation Framework brings together best practice from across the STEM education sector and forms a toolkit to help evaluate and improve a school's wider STEM provision.

Throughout this document we have provided guidance and various tools to help you implement the framework. This includes resources and links to a range of different organisations who do fantastic work in the STEM education sector.

Themes

Self-evaluation and improvement tools

Whether you are a classroom teacher using the framework to help enthuse and engage your students or a school leader looking to develop a culture of research across your school, self-evaluation is a powerful tool in driving change and achieving improvement.

The improvement process

Top tip

When developing a culture of research and innovation, it is important to get the buy-in and support of school leadership. This could involve sharing the benefits of an improved STEM culture with governors or members of the school leadership team, as well as demonstrating the need for change based on the evaluation of your schools' current STEM ethos and provision.

Growing a culture of research and innovation cannot happen overnight. Like many areas of school improvement, it is a continuous cycle powered by self-evaluation within a framework.

The R&I Framework has been designed to encourage education practitioners to reflect on their current practice and provides a roadmap of suggested actions and resources that can support the growth of research and innovation at all levels of school life.

Alongside the publication of the R&I Framework, IRIS has produced a range of tools to support with self-evaluation, improvement planning, and impact evaluation. These tools and guides include a self-assessment toolkit, student and teacher questionnaires, action plans and much more. For more information or to download these resources visit:

www.researchinschools.org/framework

Leadership, Vision & Culture

Exploring the importance and power of leadership in developing a culture of STEM, research and innovation in schools

20 Leadership, Vision & Culture

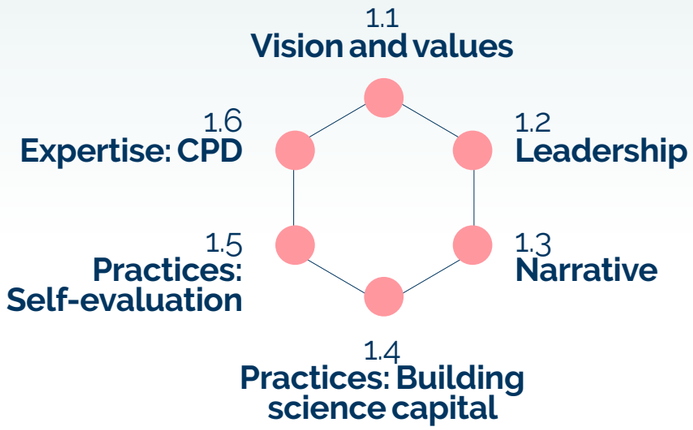
Leadership within a school is crucial as it influences every aspect of school life from day-to-day operations to the overall culture of the school.

Any type of innovation in a school requires careful consideration and planning. While class teachers and middle leaders can be the change makers and drivers, senior leaders and headteachers have a bigger reach, with the influence and resources to drive motivation.

A good STEM education is more than just preparing a few students to become the scientists of tomorrow. Schools must be proactive in ensuring that all young people can access science and feel that STEM is important and relevant to their lives. To achieve these goals, leaders must create or buy into such a vision and take an active role in building a set of beliefs that drive forward a culture of research and innovation.

Theme 1 strand map

Leadership, Vision & Culture has been designed to encourage teachers and school leaders to reflect on their vision for STEM and consider the systems and values that the school uses to develop a culture of research and innovation, whether they be implicit or explicit.



21 Case study

Dr James Allen
Head of Biology

Helston Community College
Helston, Cornwall
11-18 comprehensive school

James Allen is the type of science teacher that every student needs. Someone who opens the minds of students to what science can be. James strongly believes that students should experience authentic science to fully appreciate the subject.

"I find the complexity of the living world fascinating, and I want to help students to understand this. We are still learning so much, not just about our own planet, and it is this spirit of discovery, as well as the ability to find the answers to unknown questions, that I want to instil in students."

Dr James Allen
Head of Biology

What they researched

James' students have been involved in many research projects since the school joined IRIS in 2016. This includes Timpix, where students investigated radiation data collected by particle detectors on the International Space Station. One student became so excited about the subject that he began an independent research project looking into the impact of radiation on mealworms, with a view to them being used in space as a potential protein source for astronauts.

How the research experience benefitted students

James says "In my opinion, the way we teach science is not a true representation of what it actually is. The national curriculum, certainly beyond KS3, requires us to teach students a series of facts, with practical work being used largely to demonstrate a concept which students have been taught. This is why the work IRIS carries out is so important. It gives students the opportunity to discover what true investigative science is like, and that we don't always know the outcome of a practical exercise before we start it."

Leadership, Vision & Culture

Every school is different and unique, this framework should be used as a reflective tool rather than a checklist. We encourage you to adapt it in a way that works best for your school.

Strands	Starting out	Embedding	Established
1.1 **Vision and values**	There is a vision for STEM although this is limited to a departmental or class level. This vision is beginning to inform practice, which is changing the profile and perception of STEM.	The school has a clear vision for STEM which is supported by senior leaders and staff across the school. This vision shapes STEM, research and innovation activities across the school.	The school has a strong vision for STEM, Research and Innovation, including a set of values which guide practices. The school's vision and values are supported and promoted by senior leaders and understood by almost all staff and students.
1.2 **Leadership**	STEM, Research and Innovation is coordinated by a dedicated member of staff, although this could be on a volunteer or informal basis.	STEM, Research and Innovation is primarily driven and coordinated by middle leaders or a dedicated member of staff who has been given responsibility for this area. It has a wide reach across the school.	STEM, Research and Innovation are driven and supported by senior leaders and the governing body, with a named member of staff having overall responsibility for leadership in this area, coordinating the activities of others. It has a whole-schools' reach.
1.3 **Narrative**	There is a narrative within the school around the general importance of STEM at the national level.	There is an understanding of the importance of STEM at a national level as well as within a local context. This understanding starts to shape the schools' activities in relation to STEM, Research and Innovation.	The schools' STEM provision and opportunities provided to students are shaped from a strong understanding of the importance of STEM at a national and local level.
1.4 **Practices: Building science capital**	There is a recognition of the importance of building science capital, with some strategies in place to do so. The impact of this work is not yet reaching a significant number of students.	The school recognises the importance of building science capital and there are several effective strategies in place to do so at departmental level impacting a significant number of students.	The school is dedicated to building science capital for all students and it is well integrated into the schools' culture. The school has strong systems, strategies and routines in place in order to achieve this, impacting almost all students.
1.5 **Practices: Self-evaluation**	Through self-evaluation the school has an awareness of the reach and impact of its STEM provision.	The school's self-evaluation on the impact of its STEM provision is evidence based. This information is used to drive improvement and increase engagement in STEM.	The school's self-evaluation of its STEM provision is robust and incorporates clear measures of impact. Clear future actions are identified which will move the school towards its overall vision for STEM. The school collaborates with external partners to help with the evaluation and improvement process.
1.6 **Expertise: CPD**	STEM teachers and staff are supported to take part in CPD to develop their own substantive and disciplinary knowledge in addition to subject-specific pedagogy.	The school recognises and values the importance of subject specific CPD. This includes developing teacher substantive knowledge, disciplinary knowledge and subject-specific pedagogy. CPD for STEM teachers also focuses on building science capital while removing barriers to students engaging in STEM. This includes a focus of students becoming scientifically literate citizens.	The school is committed to empowering STEM teachers to become experts by providing effective and sustained CPD opportunities to improve their substantive and disciplinary knowledge alongside their subject-specific pedagogy. CPD for STEM teachers also focuses on building science capital and removing barriers to students engaging in STEM and becoming scientifically literate citizens. Where appropriate, senior leaders, teachers, technicians and other school staff actively promote or engage in opportunities to continue their own research including through CPD and partnerships.

The Institute for Research in Schools

Recommended resources and reading

Here are some recommended organisations, resources and reading materials to help you get started. We encourage you to explore the many other STEM organisations offering support and opportunities to schools.

ASPIRES

Whether you are a specialist STEM teacher or a school leader without a STEM background, we highly recommend reading the ASPIRES study. For over ten years ASPIRES, a mixed-methods study at UCL, has been investigating how young people form ideas around STEM. The project has led to key observations on what shapes young people's science identities, aspirations and their level of engagement in STEM. ASPIRES provides a strong evidence base to help teachers and education leaders to gain a clear understanding of the problem in order to address it.

For more information, visit:

www.bit.ly/IRIS_1

Click here to download the phase one ASPIRES project summary report:

www.bit.ly/IRIS_2

Click here to download the phase two ASPIRES project summary report:

www.bit.ly/IRIS_3

Science capital

We know that having a good teacher is one of the leading reasons, along with practical work, that students enjoy science. There are, however, many students who do not see science as important or accessible to them. Historically, we have focused on making STEM fun but evidence is now clear that we need to make it more relevant. The Enterprising Science project has looked at how teachers and schools can develop the science capital of young people and therefore change their perception that science is for them.

We've added science capital and the science capital teaching approach to theme 1 as we believe that it can be most effective when embraced and supported by school leadership and incorporated into the school's culture.

Click here to download the resources and teacher pack for the science capital teaching approach:

www.bit.ly/IRIS_4

Project STEM - Book of Insights

This research looks at the attitudes, motivations and mindsets of young people and how these affect the decisions they make on subject and career choices. particularly in relation to science, technology, engineering and maths. We've added this resource to theme 1 as it helps to understand the need to develop a culture of research and innovation in schools.

Click here to download Project STEM:

www.bit.ly/IRIS_5

26 Continued Professional Development (CPD)

Collaboration and sharing good practice amongst teachers and schools can have a positive impact on students and staff, but sometimes we need to look further afield.

External CPD opportunities are a crucial component of an effective development programme for teachers. External CPD can build skills and knowledge in an area where an existing learning community lacks expertise or needs additional support to drive improvement, including alternative perspectives or challenge. These recommended organisations have a proven track record of high quality STEM CPD which includes some aspects of research and innovation in schools.

STEM Learning

STEM Learning offers well-established and successful CPD in many areas of STEM and STEM Leadership. National residential CPD courses and local/online CPD events are complimented by thousands of educational resources covering all aspects of STEM.

For more information, visit:

www.stem.org.uk

Institute of Physics (IOP)

The Institute of Physics works to promote, develop and support excellent physics teaching through networks, CPD events or proven resources. Regardless of what stage you are at in your career, or whether you are a specialist or non-specialist physics teacher, we highly recommend the IOP to help develop and improve physics teaching.

For more information, visit:

www.iop.org/education

Royal Society of Chemistry (RSC)

The Royal Society of Chemistry (RSC) offers a well-rounded programme of training and learning that aims to support every aspect of chemistry teaching. In addition, the RSC offers teachers support through their regional teams of Education Coordinators and Programme Managers, alongside a wealth of resources to support chemistry teaching.

For more information, visit:

www.edu.rsc.org

27 Case study
Focus on enrichment and research-based science

Ms McClure
Science curriculum leader

Colton Hills
Community School
Wolverhampton
11-18 comprehensive school

What they researched

Around eight years ago, Colton Hills actively renewed its focus on enrichment and research-based science teaching. The leadership team took this decision one step further by ensuring that all students were exposed to this kind of teaching, not just a few high achieving pupils - actively instilling the belief that science is for everyone, not just a few top pupils.

As part of the school's science curriculum, students take part in programmes organised by IRIS, the Behavioural Insights Team, Ogden Trust funded National Space Centre masterclass, 'I'm a scientist' webchats, and the Medical Mavericks Academy.

For Colton Hills, creating a positive STEM culture is also about raising the profile of STEM. The school encourages students to take part in STEM competitions such as RAF Gliders and the Royal Society of Biology's Biology Olympiad. Students have had great success in the last two years - including third place in Solutions for the Planet and receiving a silver award in the Biology Challenge. Colton Hills students have also made it to the international final of the WWF Wild Wisdom Challenge.

How this culture has benefitted students

A positive STEM culture, centred on enrichment and research-based teaching which is also steeped in the belief that science is for all students has had a profound impact on Colton Hills students. Not only has it improved pupils' progress and their science capital, but it has increased students' confidence in the subject and their own abilities.

"There is no greater way to build science capital and break the stereotype that there is only one kind of scientist, than to have students confronted with scientific excellence and achievement from within their own school."

Ms McClure
Science Curriculum Leader & Associate Assistant Headteacher at Colton Hills Sixth Form

Research Opportunities & the Curriculum

Providing opportunities for students to experience the nature of real science within the curriculum and beyond

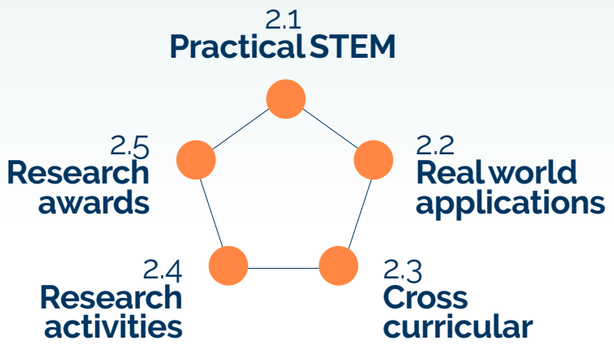
Student-led research describes activities that enable young people to experience STEM in the way that researchers do through scientific research.

Far too many students see STEM as a static body of knowledge, something that has already been done and a domain in which they are often passive participants. A strong knowledge-based curriculum is incredibly important to ensure that students know the products of science and can explain the natural world around them. It is also important that students learn about the practices and nature of science. From procedural knowledge which develops into practical skills overtime, to understanding how knowledge is established through enquiry and research.

Evidence shows that there are many benefits of student-led research, including a positive impact on learning, improved attitudes to science and increased awareness and uptake of STEM careers. Student-led research can also be effective in building science capital and engaging historically excluded groups in STEM.

Theme 2 strand map

This theme focuses on enhancing the curriculum and providing wider opportunities in STEM. Using student-led research and setting learning in a real-world-problem-solving context shows students that they can be active participants in science.



Research Opportunities & the Curriculum

Every school is different and unique, this framework should be used as a reflective tool rather than a checklist. We encourage you to adapt it in a way that works best for your school.

Strands	Starting out	Embedding	Established
2.1 **Practical STEM**	In STEM subjects procedural knowledge (how to do things i.e. use a thermometer or tri-square) is explicitly taught.	In STEM subjects procedural knowledge is valued and taught with ever more complexity over time leading to the development of skills. Students have regular opportunities to use these skills.	In STEM subjects procedural knowledge is valued and taught with ever more complexity overtime leading to the development of skills. Students have the opportunity to use these skills in innovative ways, not only enhancing and enforcing curriculum learning but also the nature of STEM and research.
2.2 **Real world applications**	The curriculum in STEM subjects is occasionally linked to real world scenarios or issues.	The curriculum in STEM subjects is regularly linked to real world scenarios or issues highlighting the importance of STEM in our lives.	Where appropriate the curriculum in STEM subjects is set in a real-world context addressing key issues or highlighting the importance of STEM in our lives. Students understand how STEM not only enables active citizenship but also empowers us all to directly address global and local issues.
2.3 **Cross curricular**	Students are given the opportunity to connect and apply their learning across STEM subjects. This usually happens through specific projects or events such as STEM cross-curricular days.	Cross-curricular work is common, and students are often given the opportunity to connect and apply their learning across STEM subjects through the curriculum.	Every opportunity is taken to work collaboratively across the curriculum to allow students to connect and apply their learning across STEM subjects. The school's leadership team supports STEM leaders to work together and the curricula of different STEM subjects complement each other in terms of both intent and implementation.
2.4 **Research activities**	Students have the opportunity take part in activities which are rooted in the principles of research.	The school provides opportunities for students to take part in longer term research activities, where the answer is not known to them.	There are opportunities for students to take part in long-term authentic research (where the answer is not known to them) at least once per year. The school is involved in external schemes or collaborates with partners to support student-led research. Where long-term authentic research opportunities are not appropriate, the school provides students with an innovative, wide range of opportunities and activities related to research. Students see themselves as producers of science rather than just consumers.
2.5 **Research awards**	Where appropriate, the school supports some students to complete a project-based award or qualification in addition to the normal curriculum offer.	Students can use their research, if they wish, to complete a project-based qualification or award as part of the school's standard offer.	At different points in their schooling students can use their research to complete a range of project-based qualifications or awards at different levels.

The Institute for
Research in Schools

32 Ideas for developing IRIS student-led research in your school

1st year

Create a research club targeted at one of the following groups:
- 11- to 14-year-olds
- 14- to 16-year-olds
- 16- to 18-year-olds

Run an IRIS beginner project for younger students or IRIS intermediate project for older students.

Tip: If looking for a beginner project, check out Carbon Researchers:

www.researchinschools.org/projects

Celebrate your students' research by presenting at an IRIS conference.

Evaluate the impact of student-led research on participating students.

Tip: Many schools find that partnering with a local university, business or STEM charity provides additional support and acts as a catalyst for student-led research.

2nd year

Expand the number of research clubs on offer – adding one club for each age group.

Ask returning students to expand their previous year's research, focusing on a particular element or question of interest.

Tip: Once you've set up the research group, encourage older students to work together independently. They can use the school's login details to access project resources from IRIS without the need of a teacher or member of staff.

Select one or two students who are interested in studying STEM after they leave school. Introduce them to original research and support them in carrying out an IRIS Original Research project. Check out IRIS' comprehensive Original Research Guide for students.

As well as attending an IRIS conference, consider hosting an internal conference or getting students to present their artefacts at school events such as parents' evenings.

Evaluate the impact of student-led research on participating students.

3rd year

Continue running research clubs.

Returning students will be experienced in research, so look at original research or more advanced projects. This could include partnering with a local university or business.

Run a small-scale trial to encourage students to use their research as a basis for an extended project qualification (EPQ) or an accreditation scheme.

Attend an IRIS conference, but also host your own. Invite members of the local STEM community to encourage students and staff to expand their research network.

Evaluate the impact of student-led research on students.

Tip: After three years of research, speak to your school leadership team about your ambitions for next year. It is important that you get buy-in and support at this stage.

4th year

Continue running research clubs.

Where possible offer research opportunities to all students in sixth form, encouraging them to complete an extended project qualification (EPQ) or an accreditation scheme.

Tip: Consider encouraging some students to apply for IRIS' Young Researcher High Potential Programme.

Introduce student-led research projects as part of the curriculum.

Create a staff research board by inviting staff from across STEM subjects to get involved in shaping the school's research offer.

Evaluate the impact of student-led research on students.

33 Recommended resources and reading

Here are some recommended organisations, resources and reading materials to help you get started. We encourage you to explore the many other STEM organisations offering support and opportunities to schools.

The Institute for Research in Schools

The Institute for Research in Schools (IRIS) develops opportunities for students aged 11 to 18 from all backgrounds to participate in authentic research while in school and make valuable contributions to the scientific community. IRIS offers a range of projects to schools, free of charge, as well as support for teachers and students, including meaningful encounters with STEM professionals.

For more information, visit:

www.researchinschools.org

Good Practical Science

Good Practical Science provides a framework for practical science in schools. Originally published in 2017 by the Gatsby Charitable Foundation, the report established ten good practical science benchmarks that schools can use to guide how they plan and deliver practical work. Benchmark 8 recommends that "students should have the opportunity to do open-ended and extended investigative projects".

For more information, visit:

www.bit.ly/IRIS_6

CREST Awards

CREST is a scheme that inspires young people aged 5 to 19 to think and behave like scientists and engineers by giving them the chance to take part in a student-led project. Students can embark on a project of their choice and receive a widely recognised award upon its completion. To support teachers, parents and students, CREST provides a wealth of resources on their website along with funding opportunities and grants open to a number of community settings and schools.

For more information, visit:

www.crestawards.org

Investigating Practical Science in the Curriculum

The British Science Association (BSA), which manages the CREST Awards, has recently produced a free curriculum-based teaching resource called *Investigating Practical Science in the Curriculum: Making it Happen*. This resource has been developed to help re-engage students with practical learning and includes top tips, ideas and guidance for teachers to embed open-ended, extended investigative practical work into the secondary science curriculum.

For more information, visit:

www.bit.ly/IRIS_7

Recommended resources and reading continued

The Royal Society Partnership Grants

The Partnership Grants Scheme from the Royal Society offers schools up to £3,000 to run investigative STEM projects in partnership with STEM professionals from academia or industry. The scheme has been designed to provide opportunities for students to develop key skills, highlight the range of STEM careers available, foster long-term relationships between schools and STEM professionals, and addresses Benchmark 8 of the Gatsby Good Practical Science Benchmarks.

For more information, visit:

www.bit.ly/IRIS_8

Neon

Neon brings together engineering experiences and resources to help teachers inspire students and bring STEM to life with real-world examples of engineering. From inspiring case studies to helping schools, business, academia and industry to connect.

For more information, visit:

www.neonfutures.org.uk

STEM Crew

STEM Crew offers a range of resources to bring science to life and help make science teaching more engaging and exciting.

For more information, visit:

www.stemcrew.org

(Extended) Project qualifications

An EPQ (Extended Project Qualification) is a project-based qualification which is usually completed alongside A-levels and is worth between 8 and 28 UCAS points. It allows students to delve into a topic that they have an interest in and carry out a focused piece of research. Universities and apprenticeship providers view the EPQ as a great way for students to get ready for higher study and develop many of the skills that they will need at university.

The EPQ is offered by several examination boards, some of which also offer project qualifications at various levels to suite the age and ability of learners.

Take a look at the following websites to find out more information about project qualifications:

Pearson – Project Qualifications:
www.bit.ly/IRIS_9

AQA – Project Qualifications:
www.bit.ly/IRIS_10

ASDAN – Extended Project Qualification:
www.bit.ly/IRIS_11

OCR – Project Qualifications:
www.bit.ly/IRIS_12

WJEC – Extended Project Qualification:
www.bit.ly/IRIS_13

Museums

Museums are a great place to illustrate the nature of science. They highlight not only what we know but also what we don't know. They show first-hand that many of the innovations that were hailed as the next big thing were soon superseded or shown to be ineffective but still helped to contribute to our collective understanding of science.

Many museums have programmes and resources that help bring STEM to life and support teachers to make links between scientific knowledge and the real world.

Real World Science – this is a network of museums across the UK that use their collections to engage students with science. The network puts experts, role models, and scientists in contact with schools to support teacher training and CPD.

For more information, visit:

www.bit.ly/IRIS_14

Science Museum Group – The Science Museum Group's learning vision is to enrich lives by igniting curiosity in science. To do this they provide teachers, schools and community groups with a wealth of resources, from ideas of how to build science capital to learning resources including being able to explore museum collections in 3D.

The Science Museum Group also runs *The Academy* which delivers research-informed training and resources for teachers and STEM professionals.

For more information, visit:

www.learning.sciencemuseumgroup.org.uk

In2ScienceUK

In2scienceUK provides young people from disadvantaged backgrounds with the opportunity to take part in STEM placements, working alongside researchers and industry professionals to get hands-on STEM experience.

For more information, visit:

www.in2scienceuk.org

Skills Builder

Although not directly linked to student-led research, the Skills Builder Universal Framework is a great resource for teaching essential skills. The framework breaks each skill into steps supporting progress for students. Student-led research is a fantastic way to support students to develop and grow essential skills and Skills Builder allows that journey to be planned and monitored effectively.

For more information, visit:

www.skillsbuilder.org

Nuffield Research Placements

Nuffield Research Placements are real-life research or development projects where Year 12 (or equivalent) students carry out a well-supervised but independent research project in STEM. This includes a placement at a host organisation.

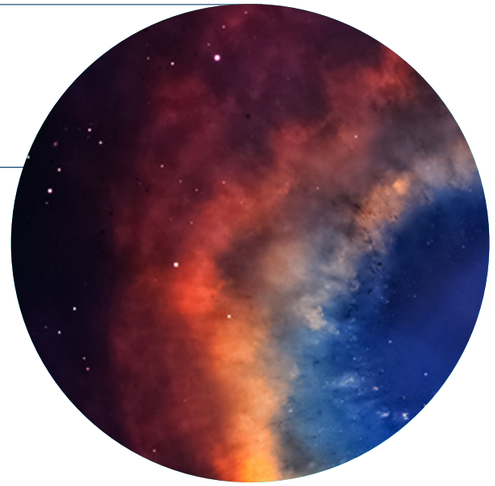
For more information, visit:

www.stem.org.uk/nuffield-research-placements

Case study
Project: Cosmic Mining

Year 12 students

Bohunt School
Hampshire
11-18 comprehensive school



What they researched

The students from Bohunt analysed data from the Spitzer Space Telescope as part of the research project Cosmic Mining. After learning how to examine and classify stellar objects, they identified 14 planetary nebulae – shells of luminous gas emitted by a dying star – by identifying the tell-tale turning point in the spectra.

Their findings could aid astronomers preparing to use the James Webb Space Telescope (Webb) – the largest, most powerful and complex space telescope to ever be built and described by NASA as the world's premier science observatory for the next decade.

How the research experience benefitted students

The project gave the students a taste of real research, and the chance to experience science and explore unchartered territory. They learned advanced skills of spectral analysis, including techniques used in professional astronomical research.

"I liked that it was completely new. We were looking at the spectra and knew from the beginning that no one had looked at them before and that was really exciting."

Helena
Student

"The content itself is so different from what we do at school: there aren't answers. It allowed us to figure out the answer."

Mary
Student

"I am incredibly proud of what my students have achieved this year whilst taking part in the Cosmic Mining project. They have learned new skills that most students wouldn't encounter until later on in university and have shown an incredible work ethic; working independently and in small groups to classify their spectra and produce their research artefacts. I look forward to seeing them become mentors, passing on their experiences to next year's participants."

Luke
Teacher

External scientific recognition

Scientists at the Science and Technology Facilities Council (STFC) acknowledged the students' contribution to Cosmic Mining.

"I've been really blown away by the dedication of all the students working on cosmic mining over the last year. They've produced so much useful data and have really quickly picked up an incredibly difficult skill interpreting spectra from telescopes. Their academic poster is a perfect demonstration of how deeply they have understood what they are doing. It wouldn't look out of place in the poster hall at the National Astronomy Meeting or any other professional astronomers' conference."

Dr Ciaran Fairhurst
STFC

Case study
Project: Ionic Liquids

Year 12 students

Sir Robert Woodard Academy
West Sussex
11-18 comprehensive school

What they researched

The students researched ionic liquids. As part of their research process, they learned how to create ionic liquids and investigated ways to manipulate them to develop a water purification technique.

How the research experience benefitted students

The students had the opportunity to experience chemistry in a real-life scientific setting and discover the creativity and the possibility of environmental solutions within an emerging field of science. They created ionic liquids that could potentially be used to absorb waste chemical dyes widely used in the textiles industry. Their work could provide a new water purification technique which could help reduce the polluting effects when this type of chemical waste is released into rivers and lakes.

The students also had the chance to work alongside a leading academic, the President of the Royal Society of Chemistry and Professor of Sustainable Chemistry, Tom Welton, and visit his world-class labs at Imperial College London. This experience has had a real impact on the students' future education and career aspirations.

"In the future I am hoping to synthesise and research medicines and specialise in biochemistry at a higher level. This work experience gave me an insight into a working lab environment."

Lucy
Student

Careers in Research & Innovation

Showing students of all abilities and backgrounds the range of opportunities available to them in STEM after they leave school

40

Careers in Research & Innovation

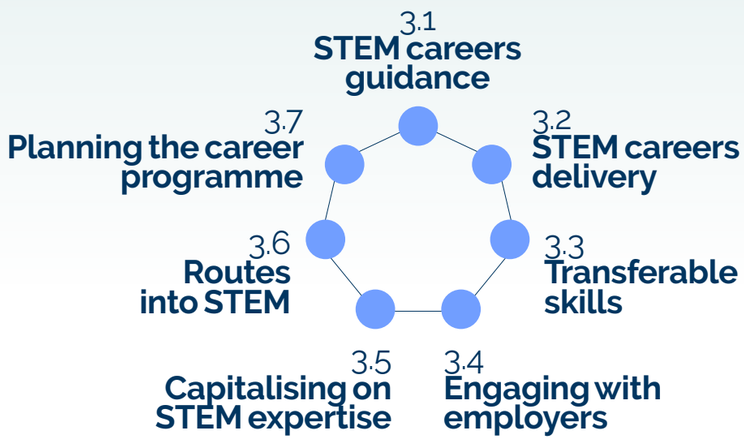
Good career guidance can be transformational for young people, particularly when it comes to raising awareness about careers in science, technology, engineering and maths.

The Government has an ambitious vision to establish the UK as a 'science superpower' and the role of science and technology is becoming ever more prominent in the economy. This represents real opportunity for young people, particularly those from disadvantaged backgrounds or individuals from under-represented groups in STEM.

It is vital that, through an effective careers programme, all students are exposed to the opportunities available to them in STEM. Part of this work must be focused on breaking down the dominant societal representations of science as being hard or reserved for certain types of people. Good career guidance must illustrate the vast array of STEM careers while also ensuring that all students understand the different routes into STEM.

Theme 3 strand map

Careers in Research & Innovation provides a framework to help build an effective STEM careers programme and embed careers education into the curriculum and school life.



THEME 3

41

Case study
Project: Original Research

Calum Arnott, IRIS Alumnus
Master's student at University of Edinburgh

Liberton High School
Edinburgh, Scotland
11-18 comprehensive school

What he researched

During his final year of high school, Calum carried out research using a TimePix particle detector from IRIS for his Advanced Higher Physics project on natural radiation.

"It was really exciting to use the technology to track and identify particles in real time – it was my first real introduction to completing a research project."

Calum Arnott
IRIS Alumnus

How the research experience benefitted the student

"Ultimately, I chose to study engineering because it is very focused around using maths and physics to solve applied problems, but the research project I carried out with an IRIS particle detector really gave me a taste of how technology can be used to aid theoretical investigation."

As part of the University of Edinburgh's rocketry team *Endeavour,* Calum recently integrated a particle detector, sourced by IRIS, into a payload flown 9,000 metres above earth for the European Rocketry Challenge. The data from this payload will be used in scientific workshops in schools. The detector is like the one Calum borrowed from IRIS many years before.

Careers in Research & Innovation

Every school is different and unique, this framework should be used as a reflective tool rather than a checklist. We encourage you to adapt it in a way that works best for your school.

Strands	Starting out	Embedding	Established
3.1 **STEM careers guidance**	The school's career education and guidance programme includes STEM-specific information.	STEM career information and guidance is well-integrated into the school's career strategy or has a separate strategy highlighting the importance of STEM.	STEM career information and guidance is well-integrated into the school's career strategy or has a separate strategy. It is supported by the school's leadership team, governors and community.
3.2 **STEM careers delivery**	STEM career information and learning opportunities generally take the form of specific events such as themed days or assemblies.	STEM career information and learning opportunities are accessed by a significant number of students and are routinely integrated into the wider school as well as specific events. For example; PSHE or careers curriculum time, assemblies, themed days, tutor time or enrichment.	STEM career information and learning opportunities are presented to all students and are well integrated into the school's STEM curriculum. Across the curriculum, teachers link learning with future opportunities in STEM and STEM careers.
3.3 **Transferable skills**		STEM career information not only focuses on STEM specific jobs but also how STEM skills are important for non-STEM jobs.	The school's STEM career programmes enables all students to understand the wide range of jobs available to them in the STEM industry, including both STEM and non-STEM jobs. Students understand the importance of (and transferability of) STEM skills in their futures.
3.4 **Engaging with employers**	Students have some opportunities to engage with employees and employers from the STEM community.	The majority of students have opportunities to engage with employees and employers from industry, academia and the wider STEM community. These meaningful encounters are with people from a diverse range of backgrounds to demonstrate that STEM is for all.	All students have multiple opportunities to engage with employees and employers from industry, academia and the wider STEM community. This includes first-hand experience of workplaces. Students are encouraged to take part in organised STEM placements. Meaningful encounters with people from a diverse range of backgrounds demonstrates that STEM is for all.
3.5 **Capitalising on STEM expertise**	The school is aware of what internal STEM careers expertise they have and staff collaborate to ensure STEM career information is accurate and appropriate.	The school is aware of what internal STEM careers expertise they have and colleagues are supported in delivering STEM careers information including through use of external support.	The school continually supports teachers, through CPD and resource provision, to develop and maintain an up-to-date knowledge of STEM careers. This is often supplemented by the use of external support such as STEM career facilitators or links with local industry or academia.
3.6 **Routes into STEM**	Students and teachers are aware of some routes into STEM once they leave school.	Students and teachers are aware of STEM opportunities available through vocational routes such as apprenticeships and T-levels as well as A-levels and university degrees. Students are appropriately supported through all routes.	The school ensures that teachers, students, parents and carers are aware of STEM career opportunities through vocational routes such as apprenticeships and T-levels. Students are aware that they can earn a salary, gain work experience and achieve qualifications equivalent to a Bachelor's or a Master's degree through an apprenticeship.
3.7 **Planning the career programme**	STEM career opportunities in the local area are mentioned to students as part of the school's career events.	STEM career opportunities in the local area are consistently highlighted to students through the school's career events and programme. Where possible, networks are built by introducing them to key employers in their area of interest. Students are taught the importance of networking.	The school's career programme is tailored to prepare students to take advantage of opportunities available to them within the local context. There is a series of planned events in the school year to build and develop student networks with local and regional employers in their career of choice. Students are able to apply their networking skills with future employers.

The Institute for Research in Schools

44 Reflection questions

Here we present a number of reflection questions targeted at teachers and school leaders. The questions can be asked in relation to both general career guidance as well as STEM specific guidance.

- What career guidance activities are happening, when are they happening and which students access them? Which students are not taking part in career guidance activities?
- Is career guidance centralised or are activities happening at the subject and departmental level? Is career information being incorporated into lessons?
- What CPD activities have taken place for staff to support them in delivering careers guidance? Are all staff aware of current best practice in relation to careers guidance?
- Are your current staff experienced in careers guidance? How can you draw on the experiences of existing staff, for example those who have entered teaching from industry?
- What impact has your school's career guidance had? What evidence of this is there? How has progression data (school leavers) changed?
- Has your school evaluated students' views on STEM careers? How has this changed over time?
- How many students have undertaken work experience? How does the school ensure that there is equity in the opportunities offered to students?
- How many encounters have students had with employers or employees? Which students have accessed these opportunities? Have these meaningful encounters been with individuals from a wide range of backgrounds?
- Do students have the opportunity to visit colleges, universities or other education providers such as apprenticeship centres? How many visits has each student been offered?
- Are all students taught about vocational routes such as apprenticeships? Are vocational qualifications and routes considered equal to traditional academic routes within your school?
- Do students get the opportunity to meet with a career guidance practitioner? How may opportunities do they get? Which students have accessed this opportunity? Which students have not met with a career guidance practitioner?
- Does your school exploit existing networks e.g. governors or parents, for the benefit of all students?

45 Recommended resources and reading

Here are some recommended organisations, resources and reading materials to help you get started. We encourage you to explore the many other STEM organisations offering support and opportunities to schools.

STEM Learning - STEM careers support for schools and colleges

STEM Learning have produced helpful resources for both careers and school leaders, as well as STEM teachers, to develop STEM careers guidance and information in their school.

For more information, visit:

www.bit.ly/IRIS_16

Useful resources for employers can be found here:

www.bit.ly/IRIS_17

Two resources that are particularly useful for STEM teachers are:

1. STEM Careers Toolkit for Careers Leaders:

www.bit.ly/IRIS_18

2. Teachers ' Guide – Linking Careers to the STEM Curriculum:

www.bit.ly/IRIS_19

Good Career Guidance

The Good Career Guidance report published in 2014 by the Gatsby Charitable Foundation identified 8 benchmarks of good career guidance. The benchmarks have been incorporated into the Government's Careers Strategy and form part of statutory guidance for schools and colleges.

For more information, visit:

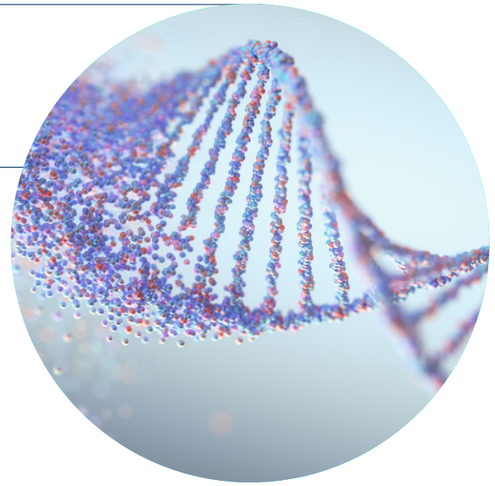
www.bit.ly/IRIS_15

46

Case study
Project: Genome Decoders

Razika Berboucha
Physics Technician

Lampton School
London
11-18 comprehensive school



What students researched

Razika's students took part in Genome Decoders, a ground-breaking research effort to improve the health of their peers in distant countries. They joined students around the country to help scientists from the Wellcome Genome Campus to annotate the genome of the human whipworm, *Trichuris trichiura*. The parasitic worm causes a Neglected Tropical Disease linked to malnutrition and cognitive developmental problems.

The Lampton students made the greatest contribution - 44 young people completed more than 2,700 annotations. Through their contribution, scientists are now closer towards completing the annotation of the protein-coding gene set.

How the research experience benefitted students

Razika values the role research can play in a young person's education but also acknowledges how she gains new skills through IRIS projects.

"IRIS' work is very important as it gives students the opportunity to access real life research. We have a national shortage of scientists and engineers and with IRIS projects I can see students getting more attracted to scientific degrees and research at university level. It also gives them an opportunity to boost their CVs."

Razika Berboucha
Technician

External recognition

In recognition of the Lampton students' impressive contribution to the annotation of the protein-coding gene set, they were asked to showcase their work at the Wellcome Genome Campus in Cambridgeshire.

Razika received the international Gratnells Science Technician of the Year Award for 2018/19.

47

Community & Collaboration

Empowering students to address issues within their local community and working with industry to provide meaningful opportunities for all

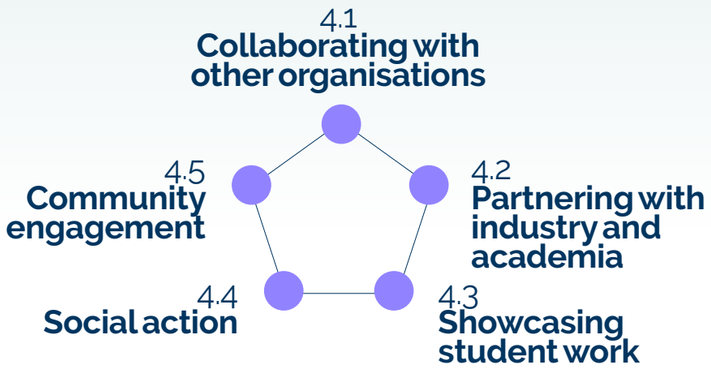
48 Community & Collaboration

Empower students to collaborate with the community and local industry. A life changing experience, it shows them they can help us solve some of the most pressing issues at a local, national and global level.

The challenges of tomorrow can't be solved by one person alone. Collaboration is at the heart of true research and innovation, so we must instil the idea of community into our young students. We must demonstrate how, collectively, we can work together to find solutions. Research in schools is about empowering students to take informed action, giving them a voice which is recognised by their community.

Theme 4 strand map

Community & Collaboration encourages school leaders and teachers to work closely with their community, local employers, parents and caregivers to provide research and innovation opportunities for all. Through collaboration, students can help find solutions to both local and national issues.



THEME 4

49 Case study
Project: Earth Observation

Year 10 students

Alec Reed Academy
London
All-through school

What students researched

Students from Alec Reed Academy tracked the Pine Island Glacier, one of the largest ice streams in Antarctica as part of the Earth Observation project. Using satellite images, they tracked the glacier's movement over a period of time.

How the research experience benefitted students

The teacher felt the project greatly increased the students' confidence in themselves and their abilities.

Sahiba, one of the students, said it gave her the opportunity to learn more about a subject she knew nothing about. She felt the project made her more aware of the impacts of environmental change.

"We all found difficulties doing some of the tasks, but we kept trying and discovering new things."

Sahiba
Student

External recognition

Two Year 10 students from Alec Reed Academy received CREST Silver Awards for their research poster.

Sahiba said receiving a CREST Award "felt amazing" and it really mattered to her as a science student with big ambitions.

"I think they deserved the award because of their enthusiasm in learning about glaciers and global warming, and because they worked hard on completing a research project based on a topic of actual relevance."

Alberto Munoz
Teacher

Community & Collaboration

Partnerships with industry, academia and the local community are a powerful tool to develop research and innovation in schools. Regardless of experience or starting points, we encourage schools and teachers to build networks and collaborate with the wider STEM community, particularly around research opportunities and social action. Remember, this framework should be used as a reflective tool rather than a checklist, adapt it in a way that works best for your school.

Strands	Starting out	Embedding	Established
4.1 **Collaborating with other organisations**	The school occasionally collaborates with STEM organisations including industry, academia and the charity sector to offer stand-alone events and opportunities to students.	The school regularly collaborates with STEM organisations including industry, academia and the charity sector to offer events and opportunities to students, parents and teachers.	The school has a strong history of collaboration and partnerships with STEM organisations and other schools. This network allows the school to offer a unique programme of STEM opportunities not only to students but also, on occasion, to the wider school community.
4.2 **Partnering with industry and academia**		Some students have the opportunity to partner with industry, academia or other individuals who can support them with a STEM project.	The school provides students with various opportunities to partner with industry, academia or other individuals who can support them with their STEM project.
4.3 **Showcasing student work**	Students are given the opportunity to showcase their STEM project or research findings with internal audiences at school events such as assemblies, parents' evenings and open evenings.	There is a culture of sharing STEM research or project work within the school. Students are given the opportunity to share their work with both internal and external audiences.	There is a strong culture of sharing and celebrating research. Students are encouraged to and supported in sharing their research findings with various networks and stakeholders.
4.4 **Social action**		Students are encouraged to use STEM research or project work to address an issue or problem within their school. This often involves an aspect of student-voice.	Students are empowered to use STEM research to take social action including to address local, real life issues within the school's community and the wider world.
4.5 **Community engagement**		Parents and carers are actively engaged in supporting and encouraging student research or project work.	Parents, carers and the local community are actively engaged in supporting and encouraging student research and project work. The community plays an important role in establishing networks to provide students with meaningful opportunities in STEM.

The Institute for Research in Schools

52 Recommended resources and reading

Here are some recommended organisations, resources and reading materials to help you get started. We encourage you to explore the many other STEM organisations offering support and opportunities to schools.

IRIS Conferences

Each year IRIS hosts a number of conferences across the UK, allowing students to share their research with their peers from other schools and the wider academic community.

For more information, visit:

www.researchinschools.org/conferences

Youth Social Action Toolkit

The Youth Social Action Toolkit has been designed to support young people to participate in social action. The toolkit has resources for young people and their families, employers, career coordinators, and educators. Research and evidence show that youth social action has a range of benefits to young people and can bring about real change within the community.

For more information, visit:

www.youth-social-action.careersandenterprise.co.uk

The Big Bang Fair

The Big Bang Fair is an annual celebration of STEM for young people. The event features theatre shows, hands-on activities, interactive workshops, excellent careers information and meaningful encounters with STEM professionals from a wide range of backgrounds.

The Big Bang Programmes also runs the annual Big Bang Competition and provides resources for online or in-person activities.

For more information, visit:

www.thebigbang.org.uk

Young Scientists Journal (YSJ)

The Young Scientists Journal is an international peer-reviewed science publication written, reviewed and produced by school students aged 12 to 20. The YSJ provides a place for young people to publish and share their scientific research.

For more information, visit:

www.ysjournal.com

53 Engaging your community

When families, communities, local services, businesses and schools work together to support young people, amazing things can happen.

From empowering young people to address and solve problems impacting the local community to providing opportunities for students to take part in unique work placements, here are some ideas of how to engage with your community:

1. Reach out to your school's existing stakeholders

Teachers, parents and governors have a wealth of untapped resources which exist within their personal and professional networks. Ask them to reach out to their networks and seek opportunities for the school to collaborate. From governors talking about their careers and offering work placements, to parents running masterclasses or mentoring students, there are many possibilities. It always helps to be clear on what you are looking for and to formalise the collaboration campaign with a leaflet or web page.

2. Work with your wider community

It is important to create connections within the local community. One of the best ways to do this is through community walks. With the support of students, create a campaign asking local residents to suggest ideas for how the school and students can support the wider community. Explore how the community can reconnect, collaborate and share their experience, skills and time to make a difference to your young people. Get students to write to local businesses and universities asking to work together. Go out into the community and hand deliver these leaflets and letters. It provides a great chance for the community to meet students and staff.

3. Connect the curriculum with the community

Ensuring students have a strong foundation of knowledge is incredibly important, however, it doesn't need to be learnt in isolation from the real world. Young people must understand the relevance in what they are learning. This can be done by linking knowledge to the local context. For example, by inviting community partners who are subject matter experts to speak to students.

Community collaboration can also be a powerful tool for teachers. Subject experts from industry and academia can provide CPD to teachers, ensuring that their subject knowledge is current and up-to-date.

Case study
Students drive green policy

For the past few years, Ladies' College Guernsey has been taking part in Carbon Researchers. In this project, students calculate and consider their schools' carbon footprint and devise a strategy to reduce it. After a positive response from the school, they decided to organise a climate strike with young people across Guernsey to encourage other schools to develop their own carbon reduction plan. They even met with minsters from local government. They expanded their research project to work with local businesses, industry and government to reduce Guernsey's carbon footprint.

Case study
Project: Original Research

Year 9 students

Liverpool Life Sciences UTC
Liverpool
Technical college specialising in science, engineering and healthcare

What students researched

Students at Liverpool Life Sciences UTC have begun a new research project examining whether mealworms can digest plastic waste, potentially providing a solution to one of humanity's greatest environmental challenges.

The year 9 students, known as the Real Meal Group, have been studying mealworm larvae under a scanning electron microscope (SEM) – a powerful microscope that scans a beam over an object to obtain information about its surface topography and composition – to investigate the digestive abilities of the animal. The college has been loaned the SEM in a partnership led by IRIS with the Royal Microscopical Society, the Natural History Museum, Hitachi High Technologies and Oxford Instruments.

So far, the young researchers have found traces of microplastic waste in the gut of mealworms. They now want to find out what proportion of the plastic waste is digested into harmless substances – previous research suggests it can be up to 50 per cent. Once they have completed their research, the students intend to develop a household plastic waste digester box that uses mealworms to break down non-recyclable plastics. Two students are designing the box using CAD software Autodesk Fusion 360.

Another student is looking into how people could remotely monitor the box and make changes from their smart phones. This involves working out how to connect a series of sensors to a microcomputer to monitor conditions in the digestor box and trigger heaters and fans to maintain temperature and humidity within optimal ranges for the mealworms.

How the research experience benefitted students

The students gained new research skills and knowledge, including how to use a scanning electron microscope.

With an estimated five million tonnes of plastics used every year in the UK, this research project allowed the students to use science in a creative, yet practical way to potentially address a global issue.

Capturing Talent & Removing Barriers

Proactively challenging established stereotypes and misconceptions in STEM, building science capital for all and creating a culture of openness and inclusivity

56 Capturing Talent & Removing Barriers

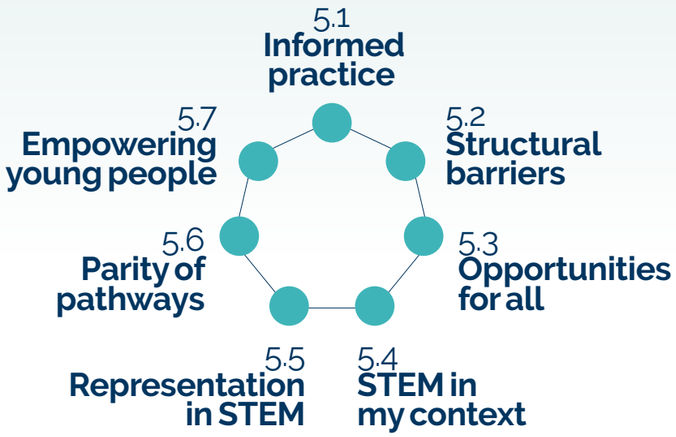
As practitioners, we must understand the barriers that prevent participation in STEM. Only then can we change our practice to truly reflect a vision of STEM for all.

For many young people in school, there are still significant barriers to engagement in STEM, meaning that their views and attitudes towards STEM are unlikely to change without a shift in approach from educators. Thanks to research, we now have an evidence-based understanding of engagement issues along with effective tools and strategies to help breakdown barriers and capture talent.

Teachers, school leaders and the wider STEM community must accept that an effective STEM education is based on more than knowledge acquisition. Schools must build science capital, challenge the negative dominant societal representations of science, establish and promote equitable pathways into STEM and empower students to become active participants in science.

Theme 5 strand map

Capturing Talent & Removing Barriers supports educators at all levels to proactively challenge damaging stereotypes and misconceptions in STEM. The theme focuses on building science capital for all and creating a culture of openness and inclusivity in relation to science, technology, engineering and maths.



57 Case study
Project: Cosmic Mining

Amy Walters
Student

Plymouth High
School for Girls
Plymouth
11 to 18 grammar school

What the student researched

During lockdown, Amy decided to take part in IRIS' Cosmic Mining at home project, to apply some of her A-level astronomy knowledge and hone her research skills. She analysed data from the Spitzer Space Telescope, which included classifying stellar objects.

How the research experience benefitted the student

"It was interesting and exciting to read around the content I covered at A-level and apply my knowledge to research that is essential for us to further our understanding of the Universe. The project advanced my independent research skills and has given me an overview of what research projects involve."

"It is unsettling not knowing whether term will start on-time or if it will involve online teaching. This experience has been useful since it promotes online, self-supported learning. I certainly feel more ready and confident, no matter if I start my degree in person or online."

"I have a conditional offer to study design engineering at Imperial College London next year, and therefore I need to have good foundations in physics. I am passionate about astronomy and want to get involved where I can, especially since I have the time in lockdown which I want to use wisely to prepare for university."

Amy
Student

Capturing Talent & Removing Barriers

Every school is different and unique, this framework should be used as a reflective tool rather than a checklist. We encourage you to adapt it in a way that works best for your school.

Strands	Starting out	Embedding	Established
5.1 **Informed practice**	The school is aware of the major barriers that prevent young people, particularly those from historically excluded groups, from becoming engaged and involved in STEM. As a result, the school employs some strategies to overcome these barriers.	The school demonstrates a strong understanding of the barriers preventing its students from engaging in STEM, including those from historically excluded groups. The school has a robust approach to overcoming these barriers ensuring that STEM is open to all students.	The school has a strong understanding of the barriers that prevent its students from engaging in STEM and seeing STEM as a possible future career path. This is particularly true for those students from historically excluded groups in STEM. In response, the school is strategic and innovative in its approach to demonstrate that STEM is for all and to breakdown barriers to ensure that STEM is accessible and equitable. The school's approach is research-led.
5.2 **Structural barriers**		The school is aware of how its own systems, structure and routines, may inadvertently reduce equity of and participation in STEM e.g. extremely high entry requirements or the selective nature of triple science courses. There are some strategies to address these issues in order to show that science is for all.	The school is proactive in identifying and changing any structural inequalities in their STEM provision or practices which perpetutate dominant educational and social representations of science e.g. science being 'masculine' or reserved for those who are 'clever' or 'science-y'.
5.3 **Opportunities for all**	Opportunities to take part in a range of STEM extra-curricular activities or informal science learning are available to some students.	Opportunities to take part in a range of STEM extra-curricular activities or informal science learning are available to most students.	Opportunities to take part in a range of STEM extra-curricular activities or informal science learning are available to every student. Significant thought is given to the barriers that some students face in attending such activities, and steps are taken to mitigate or remove these barriers.
5.4 **STEM in my context**		The school works with students to help them recognise how their existing skills, knowledge and experiences are related to STEM.	The school works with students to help them recognise how their existing skills, knowledge and experiences are related to, and useful in, STEM.
5.5 **Representation in STEM**	The school understands the importance of representation and some efforts are made to organise meaningful encounters that expose students to individuals from a range different backgrounds who work in STEM.	Positive STEM role models from a diverse range of backgrounds are often shared with students.This happens both in curriculum time as well as extra-curricular activities and may include meaningful encounters as well as case studies or video profiles.	Significant efforts are made to share role models from a diverse range of backgrounds with students. Extensive use is made of opportunities to engage with a range of STEM professionals, in addition to case studies or video profiles of those working in STEM. The school makes every effort to also show role models who took a range of routes into STEM.
5.6 **Parity of pathways**	Teachers and Senior Leaders are aware of both vocational and academic pathways. There is an awareness of the opportunities offered by vocational pathways, for example degree level apprenticeships, and these are discussed with some students.	Students have a strong understanding of vocational and academic pathways. The opportunities offered by vocational pathways, for example degree level apprenticeships, are discussed with most students. There is recognition that vocational pathways may be suitable for students of all abilities.	Where appropriate, parity is given by teachers and leaders to vocational and academic pathways. The opportunities offered by vocational pathways (for example degree level apprenticeships) are discussed with all students; there is recognition that such pathways may be suitable for a wide range of students. The school engages with organisations to provide students with knowledge and opportunities linked to vocational pathways.
5.7 **Empowering young people**	There are systems in place to allow students to express their views about the school's STEM provision.	Student voice is highly valued within the school and carefully considered when evaluating and planning its STEM provision.	The school empowers students to take ownership and become decision makers in relation to the school's STEM provision.

Recommended resources and reading

Here are some recommended organisations, resources and reading materials to help you get started. We encourage you to explore the many other STEM organisations offering support and opportunities to schools.

The YESTEM Project & Equity Compass Tool

Youth Equity + STEM (YESTEM) brings together researchers and practitioners to develop practices and tools that support equitable youth pathways into STEM.

For more information, visit:

www.yestem.org

As part of this project, the YESTEM team have developed the Equity Compass: a tool for supporting socially just practice. The Equity Compass has been designed to help practitioners ensure that STEM provision is equitable and socially just. It is a fantastic reflective tool which ensures that any action is with participants rather then being done to or for them.

For more information about the Equity Compass or to download the tool click here:

www.yestem.org/tools

STEM Ambassador Programme

The STEM Ambassador Programme from STEM Learning has over 37,000 volunteers across the UK. These volunteers come into school either virtually or face to face, free of charge and help to bring STEM to life. STEM Ambassadors make an impact by supporting learning, illuminating careers and raising aspirations.

More information about the STEM Ambassador Programme can be found here:

www.stem.org.uk/stem-ambassadors

ASPIRES

Whether you are a specialist STEM teacher or a school leader without a STEM background, we highly recommend reading the ASPIRES study. For over ten years ASPIRES, a mixed-methods study at UCL, has been investigating how young people form ideas around STEM. The project has led to key observations on what shapes young people's science identities, aspirations and their level of engagement in STEM. ASPIRES provides a strong evidence base to help teachers and education leaders to gain a clear understanding of the problem in order to address it.

Read more about the ASPIRES Research Study here:

www.bit.ly/IRIS_1

Click here to download the phase one ASPIRES project summary report:

www.bit.ly/IRIS_2

Click here to download the phase two ASPIRES project summary report:

www.bit.ly/IRIS_3

Science capital

We know that having a good teacher is one of the leading reasons, along with practical work, that students enjoy science. There are, however, many students who do not see science as important or accessible to them. Historically, we have focused on making STEM fun but evidence is now clear that we need to make it more relevant. The Enterprising Science project has looked at how teachers and schools can develop the science capital of young people and therefore change their perception of science.

For more information, visit:

www.bit.ly/IRIS_4

Chemistry for All

The Royal Society of Chemistry carried out a five-year research and outreach study to investigate the barriers to participation in post-16 UK chemistry education. The report identified barriers across 4 main themes and found that such barriers could be overcome through purposeful and carefully planned intervention.

Chemistry for all also recommends a number of steps that outreach providers, policymakers, educators and parents can all take to overcome the barriers that prevent young people from pursuing a career and further study in chemistry.

Click here to access Chemistry for All from the Royal Society of Chemistry:

www.rsc.li/3566fha

Stemettes

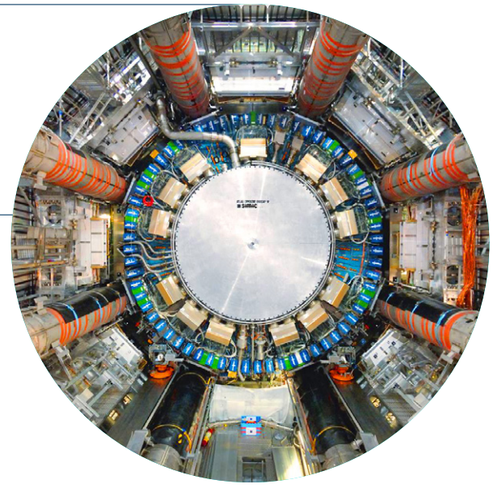
Stemettes is a social enterprise working to inspire the next generation of young women and young non-binary people to enter STEM. Through a range of programmes, Stemettes demonstrates the diversity of people already in STEM, showing the next generation that girls do STEM too.

Click here to find out more:

www.stemettes.org

Case study
Projects: Higgs Hunters & Original Research

Student Higgs Hunters present to ATLAS scientists at CERN



What the students researched

As part of IRIS' Higgs Hunters project, UK students analysed CERN collider data. The data, originally acquired from the ATLAS experiment, had been previously classified by thousands of citizen scientists from 170 countries in the search for undiscovered particles, coined Baby Higgs.

Each group of students generated their own investigation, choosing an aspect to research, producing results and analysing them. Students' analysis included clustering algorithms, complex machine learning algorithms, and databases for large data analysis.

Students presented their work to scientists at the University of Oxford.

How the research experience benefitted the students

Budding young physicists experienced the excitement of being part of a research effort which could potentially extend the frontier of physics. Led by Professor Alan Barr from the University of Oxford, students were given background information on what scientists knew about these undiscovered particles and learned how to classify and analyse data.

"I really enjoyed working on the Higgs Hunters project, as it allowed me to apply my understanding of maths, physics and computing onto a project with real world applications."

Elika
Student, Camden School for Girls

"The process was challenging but it was a challenge that captivated not only the mind but also the heart and that's just one of the many reasons why this unique experience will forever remain engraved in the memories of so many."

Shameer
Student, Claremont High School Academy

References

References

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: *Young people's science and career aspirations, age 10-19*. London: UCL Institute of Education. Available at:

www.discovery.ucl.ac.uk/id/eprint/10092041/6/Moote_9538%20UCL%20Aspires%202%20report%20online%20version.pdf
(Accessed 17 January 2022).

Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B., & Willis, B. (2013). *ASPIRES: Young people's science and career aspirations*, age 10-14. London: King's College. Available at:

www.kclpure.kcl.ac.uk/portal/files/64130521/ASPIRES_Report_2013.pdf
(Accessed 17 January 2022).

Bennett, J., Dunlop, L., Knox, K. J., Reiss, M. J., & Torrance Jenkins, R. (2018). Practical independent research projects in science: a synthesis and evaluation of the evidence of impact on high school students. *International journal of science education*, 40(14), 1755-1773.

Campaign for Science and Engineering. (2014). *Improving Diversity in STEM*. London: CaSE. Available at:

www.sciencecampaign.org.uk/resource/ImprovingDiversityinSTEM2014.html
(Accessed: 13 January 2022).

Cilauro, F., Paull, G. (2019). *Evaluation of Nuffield Research Placements: interim report*. London: Nuffield Foundation. Available at:

www.nuffieldfoundation.org/wp-content/uploads/2019/12/NRP-Evaluation-Interim-report-June-2019-1.pdf
(Accessed 17 January 2022).

Cordingley, P., Higgins, S., Greany, T., Buckler, N., Coles-Jordan, D., Crisp, B., Saunders, L., Coe, R. (2015). *Developing Great Teaching: Lessons from the international reviews into effective professional development*. London: Teacher Development Trust. Available at:

www.tdtrust.org/about/dgt/
(Accessed: 13 January 2022).

Drymiotou, I., Constantinou, C. P., & Avraamidou, L. (2021). Enhancing students' interest in science and understandings of STEM careers: the role of career-based scenarios. *International Journal of Science Education*, 1-20.

Dunlop, L., Knox, K. J., Bennett, J. M., Reiss, M., & Torrance Jenkins, R. (2019). Students becoming researchers. *School Science Review*, 85-91
.

Dunlop, L., Knox, K. J., Turkenburg, M. G. W., & Bennett, J. M. (2019). *Practical, open-ended and extended investigative projects in science*. White Rose University Consortium. Available at:

www.eprints.whiterose.ac.uk/146914/
(Accessed 17 January 2022).

EMSI. (2018). *Focus on the demand for STEM jobs and skills in Britain*. UK:EMSI. Available at:

www.economicmodelling.co.uk/wp-content/uploads/2018/12/STEM-Report_vWEB.pdf
(Accessed: 13 January 2022).

Fouad, N., Hackett, G., Haag, S., Kantamneni, N. and Fitzpatrick, M. E. (2007). *Career choice barriers: environmental influences on women's career choices.* Paper presented at the Annual Meeting of the American Psychological Association Convention, San Francisco, CA, August

References
continued

HM Government. (2017). *Industrial strategy: Building a Britain fit for the future*. Available at:

www.assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf
(Accessed: 13 January 2022).

HM Government. (2020). *UK Research and Development Roadmap*. Available at:

www.assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/896799/UK_Research_and_Development_Roadmap.pdf
(Accessed 13 January 2022).

Holman, J., Hickman, M. and Leevers, H., 2016. *Young Researchers: Reflections from Wellcome on the Impact of Doing Research Projects*. Wellcome Trust. Available at:

www.wellcome.org/sites/default/files/reflections-on-impact-of-doing-research-projects-wellcome-apr16.pdf
(Accessed 17 January 2022).

Institute for Research in Schools. (2019). *2019 Teacher Survey Final Report*. Internal IRIS report. Unpublished.

Institute for Research in Schools. (2020). *IRIS evaluation report. Internal IRIS report*. Unpublished.

Jenkins, E. and Nelson, N. (2005). Important but not for me: students' attitudes towards secondary school science in England. *Research in Science and Technological Education*, 23 (1), 41-57.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction: what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, 47, 474–496.

Moote, J. K., Williams, J. M., & Sproule, J. (2013). When students take control: Investigating the impact of the CREST inquiry-based learning program on self-regulated processes and related motivations in young science students. *Journal of Cognitive Education and Psychology*, 12(2), 178-196.

National Audit Office. (2018). *Delivering STEM (science, technology, engineering and mathematics) skills for the economy*. London: NAO External Relations (DP Ref: 116-2-001) Available at:

www.nao.org.uk/wp-content/uploads/2018/01/Delivering-STEM-Science-technology-engineering-and-mathematics-skills-for-the-economy.pdf
(Accessed: 13 January 2022).

Royal Society of Chemistry. (2020). Chemistry for All: *Reducing inequalities in chemistry aspirations and attitudes*. London: Available at:

www.rsc.org/new-perspectives/talent/is-chemistry-accessible-for-all/
(Accessed 17 January 2022).

Rushton, E.A. and Reiss, M.J., 2019. From science teacher to 'teacher scientist': exploring the experiences of research-active science teachers in the UK. *International Journal of Science Education*, 41(11), pp.1541-1561.

Saunders, M.E., Roger, E., Geary, W.L., Meredith, F., Welbourne, D.J., Bako, A., Canavan, E., Herro, F., Herron, C., Hung, O. and Kunstler, M., 2018. Citizen science in schools: Engaging students in research on urban habitat for pollinators. *Austral ecology*, 43(6), pp.635-642.

Song, S., & Mustafa, M. (2015). Factors Impacting on Teachers' Job Satisfaction Related to Science Teaching: A Mixed Methods Study. *Science Education International*, 26(3), 358-375.

STEM Learning. (2018). *Skills shortage costing STEM sector £1.5bn*. Available at:

www.stem.org.uk/news-and-views/news/skills-shortage-costing-stem-sector-15bn
(Accessed: 13 June 2021).

Stock Jones, R., Annable, T., Billingham, Z., & MacDonald, C. (2016). Quantifying CREST: What impact does the Silver CREST Award have on science scores and STEM subject selection. *A Pro Bono Economics research report for the British Science Association*. Available at:

www.britishscienceassociation.org/Handlers/Download.ashx?IDMF=9aaf06e4-f24a-435c-9991-cbf6edd1293c
(Accessed 17 January 2022).

The Education Hub. (2021). *More young people are taking STEM subjects than ever before*. Department for Education Education Hub Blog. Available at:

www.educationhub.blog.gov.uk/2021/02/09/more-young-people-are-taking-stem-subjects-than-ever-before/
Accessed: 13 January 2022).

The Gatsby Charitable Foundation. (2017). *Good practical science*. Available at:

www.gatsby.org.uk/uploads/education/reports/pdf/good-practical-science-report.pdf (Accessed: 17 January 2022).

Wellcome Trust. (2020). *Young people's views on science education: Science Education Tracker 2019, wave 2*. Available at:

www.wellcome.org/reports/science-education-tracker-2019
(Accessed 17 January 2022)

Wise. (2019). 2019 Workforce Statistics – *One Million Women In STEM In The UK*. Available at:

www.wisecampaign.org.uk/statistics/2019-workforce-statistics-one-million-women-in-stem-in-the-uk/
(Accessed 13 January 2022)

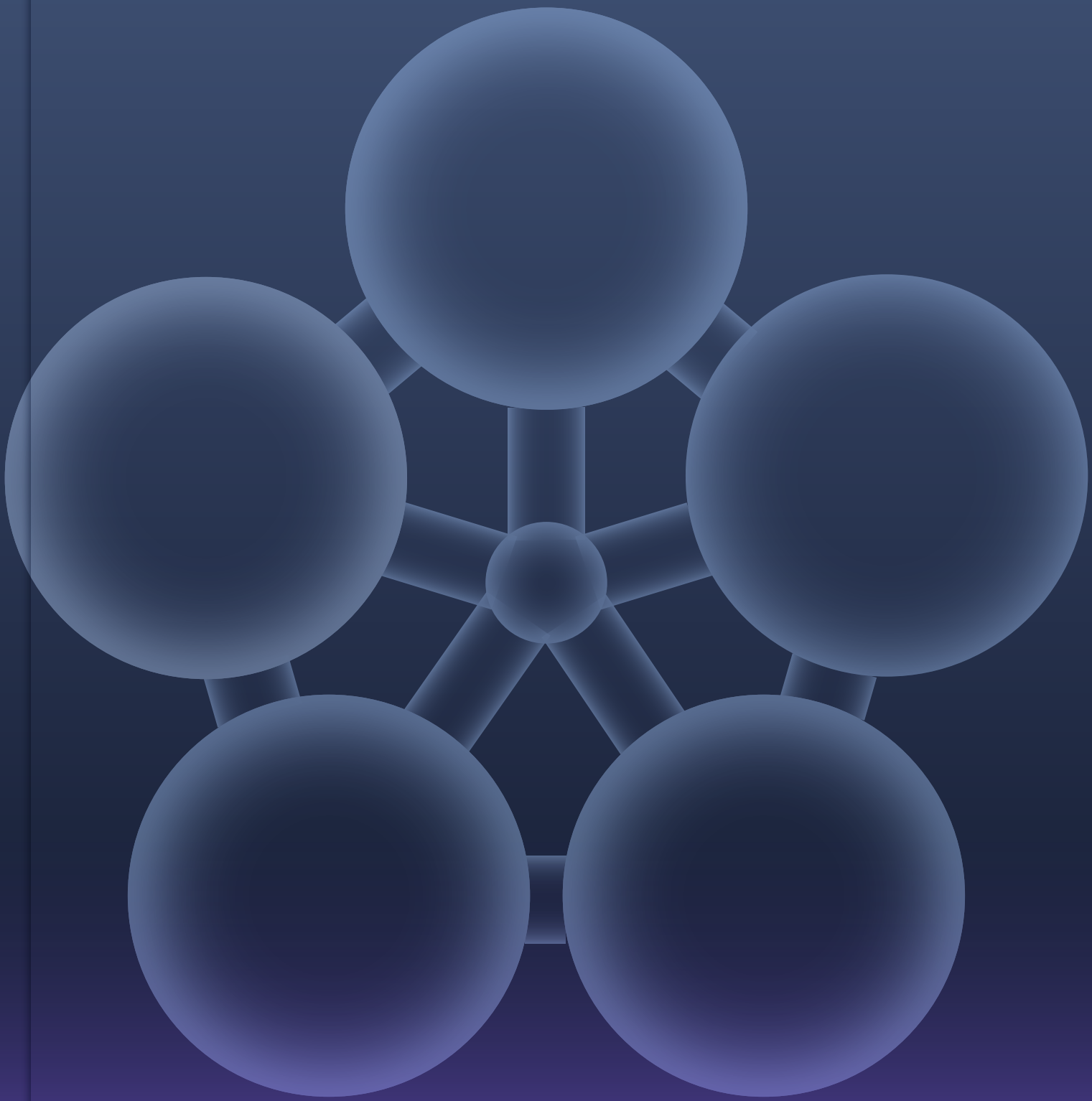
Notes

The STEM Research
& Innovation Framework

The Institute for
Research in Schools

220422

www.researchinschools.org
@ResearchInSch
info@researchinschools.org



IRIS The Institute for Research in Schools