Education research

Evaluation of the Wellcome Trust Camden STEM Initiative

Full report
June 2012

wellcome trust

Report

Draft report for the Wellcome Trust

Evaluation of the Wellcome Trust Camden STEM Initiative

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January 2012

Published in March 2012
by the National Foundation for Educational Research,
The Mere, Upton Park, Slough, Berkshire SL1 2DQ
www.nfer.ac.uk

How to cite this publication:
Straw S, MacLeod S and Hart R (2012). Evaluation of the Wellcome Trust Camden STEM Initiative. Slough: NFER.

Contents

Cross-curricular activities can help improve teaching as they help teachers contextualise their learning; they make them more aware of the links between the other subjects, and they learn about the application of the subjects from the outside STEM people coming in and talking to the pupils. (Teacher)

Pupils are now seeing the connections between the three subjects in their lessons. They are more interested, motivated and encouraged, and they have enjoyed the activities they have undertaken. (Teacher)

Being able to point pupils toward the practical uses for maths (i.e. within science and technology) has been one of the best benefits. Because so often they say 'When are we ever going to have to use this...?' (Teacher)

You realise the subjects are more important when you see how they work together. You see how you use maths with the other subjects and see that it's more important. You see the links between the subjects. (Pupil)

It makes us understand the relevance the [STEM] subjects have in our lives. (Pupil)

If people were aware that every job you do needs maths and often science it would make a difference. [Pupils] should know why they have to do it. (Pupil)

Executive summary

Introduction

This report presents the findings of an evaluation of the Wellcome Trust's Camden science, technology, engineering and mathematics (STEM) Initiative, which provided funding to eight Camden schools to develop interdisciplinary projects. Projects spanned the two academic years 2009/10 and 2010/11, with most schools starting planning and delivery in the spring and summer term of 2009. Two key delivery models were used:

- the development and piloting of new schemes of work
- the development and delivery of enhancement and enrichment activities (e.g. a themed day or series of themed days, a dedicated STEM week, after-school STEM clubs, visits out of school and visits in school from STEM Ambassadors).

The schools that focused their energies on developing new schemes of work often also delivered STEM enhancement and enrichment activities.

Background to the Camden schools and their projects

The background of the eight participating schools varied in terms of their type, the characteristics of their intake and their attainment levels. School types included mixed and single sex, comprehensive and special, and there were varied specialisms – from music and arts to science with mathematics. The percentage of pupils eligible for free school meals, a measure of socioeconomic status, ranged from 17 to 69 per cent, and the percentage of young people identified as having special educational needs ranged from 8 to 50 per cent in the seven mainstream participating schools. The standard measure of attainment, five GCSEs at grades A* to C including English and mathematics, ranged from 37 to 76 per cent across the seven mainstream schools, against a national average of 55 per cent.

Project delivery and progress

The Wellcome Trust gave schools a small grant (£10 000 over two years) and the freedom to devise a project that fitted their current stage of development in relation to STEM and individual needs. As a result, schools delivered a wide range of projects with different scope and foci. The money provided was used to pay for:

- additional responsibility payments for staff
- staff to run after-school activities
- supply cover to enable staff to work together to plan activities
- new resources, materials and equipment (e.g. data loggers, medical equipment, materials to build a wind turbine and solar heating panels)
- professional development for teachers
- pupil trips and visits from external speakers and facilitators.

Schools' progress in the first year was very good given that interdisciplinary STEM work had not previously been explicitly supported. All schools continued to successfully deliver a wide range of STEM activities in the second year of the project, targeted mostly at Key Stage 3 pupils, although there have been some challenges in delivering all the activities originally planned.

Schools varied in their arrangements for leading and managing their projects, and some changes to the leadership and management took place over the second year.

Outcomes

The STEM Initiative resulted in a range of important outcomes for pupils, teachers and schools.

The outcomes for pupils included:

- raised awareness of, and engagement in, STEM subjects
- learning new things in different ways (e.g. through exposure to outside professionals, and trips to careers events and STEM-related organisations and museums)
- increased enjoyment of STEM subjects (e.g. through their involvement in contextualised 'real world' and practical activities and being given greater freedom to use their own initiative and be creative)

- development of transferable skills useful for future study and employment (such as communication, teamwork, problem solving, planning and organisation, research, and time management)
- increased understanding of the links between the STEM subjects, especially between mathematics and other STEM subjects (including an awareness that they are linked together in the world of work and within STEM careers)
- increased understanding of the importance of STEM subjects for work and life in general (this was most pronounced for mathematics)
- greater awareness of STEM careers and what they involve (often achieved through the input of outside professionals)
- increased interest in STEM study and careers.

Some teachers and pupils have also tentatively suggested that pupils' increased interest in and motivation to learn the STEM subjects will lead to higher attainment.

The pupil outcomes highlighted above primarily relate to the enhancement and enrichment activities that pupils have been involved in, as the delivery of new schemes of work is still at an early stage. In most schools, these outcomes have been achieved for whole year groups – mainly Key Stage 3 – but in some cases, the target group has been gifted and talented pupils.

The outcomes for teachers included:

- improved relationships with staff in other STEM departments, especially for the designated STEM leads
- increased awareness of the curriculum in other STEM subjects and potential links, most evident in schools focusing on changes to schemes of work
- increased confidence in undertaking interdisciplinary projects
- new learning and skills (e.g. from undertaking practical and applied and teamwork activities)
- higher expectations of what pupils can achieve, particularly in relation to topics pupils usually find difficult
- increased enjoyment and enthusiasm (e.g. through being given the opportunity to be more innovative and creative with the curriculum).

The outcomes for schools included:

- increased awareness of and commitment to interdisciplinary STEM activity among senior leaders and staff in general
- closer links between the STEM departments at teacher level and increased formalisation of cross-departmental working
- increased confidence of teachers in cross-departmental working
- a perception of improved staff retention through new challenges and professional development.

In relation to the sustainability of these early outcomes, it is important that – where the focus of schools is on enhancement and enrichment activities rather than embedding changes in schemes of work – pupils experience ongoing opportunities to engage in these types of interdisciplinary activities (e.g. at least once a term).

What is working well

Schools identified several key areas in which aspects of their projects worked well and described several features of each of them that ensured the success of the project.

Senior leadership commitment to and support of the STEM agenda

- the commitment of senior leaders to the STEM agenda and their support of staff and activities are of key importance, particularly for the sustainability of activities.

Management and staffing

- having a designated STEM Coordinator or STEM leads in each department who take responsibility for the work; ideally, these staff should receive a responsibility payment, share the workload and engage other staff from across the STEM departments
- allocating staff to the work who are passionate about STEM
- ensuring that the staff involved feel that their work is appreciated and valued
- having a clear action plan that outlines roles and responsibilities, aims, objectives, activities and timescales, and outcomes (particularly outcomes for pupils) and details how progress will be tracked
- providing regular information to staff and sharing learning and resources so that they are clear about their role in the project and the delivery of lessons and activities is made as easy as possible
- having an openness and enthusiasm for doing things differently and an appetite for innovation
- making clear the benefit to teachers in terms of their own professional development to help ensure they are motivated to take part
- putting in place administrative support to speed up progress.

Regular meetings and planning time

- having regular, designated time off-timetable for planning or paying for supply cover to allow meetings to take place in school time, without which sustainability is likely to become an issue.

Promotion and publicity

- developing and maintaining a high profile for STEM in schools ensures that pupils are engaged with the work; this should be done in a range of ways, including the use of notice boards and assembly time.

Delivery

- practical activities, group working, problem solving, researching and debating have been found to work particularly well. Pupils also find activities engaging when they are set within real-life contexts, and this was particularly successful in mathematics where it helped pupils to see the relevance of what they were learning
- teachers running the activities should be confident in doing so, and teachers who are less confident should be properly supported
- using outside professionals to lead or support activities can be very effective – providing pupils with greater insights into STEM careers, enthusing them about STEM more generally and providing them with positive role models
- older students delivering activities, with their views often influencing those of younger children
- being properly resourced, with the necessary materials and equipment – the Wellcome Trust funding has been particularly appreciated in this regard
- taking pupils off-timetable for participation in enrichment activities: this is less complicated logistically than delivering them within the existing timetable and allows more to be achieved with the entire day solely focused on STEM
- taking advantage of the increased flexibility within the curriculum at Key Stage 3 to deliver enrichment activities and develop schemes of work. It is particularly beneficial to provide a STEM 'boost' to pupils in Year 9 before they make their GCSE choices
- gathering feedback from pupils regarding what is and is not working, how they are benefiting and what could be improved
- starting small and developing the programme gradually.

Examples of successful activities included: mapping schemes of work to identify the links between the subjects; teaching the Key Stage 4 curriculum in an entirely interdisciplinary way; STEM homework exercises; STEM enhancement and enrichment activities (including STEM clubs) on a range of themes; the use of the school garden for experiments and data collection and analysis; the use of pre-prepared and external resources; a STEM quiz in the school diary; adaptations of PowerPoints so they included a STEM logo to indicate when links with other STEM subjects were being made; and staff in STEM departments working together at options evenings to encourage further STEM study.

These are just some of the activities undertaken and demonstrate the diversity of things that encourage STEM interdisciplinary activity, some of which require low-level

buy-in in terms of staff time, school commitment and money, and some of which require a higher level of buy-in.

What challenges and barriers are being faced?

Challenges were identified in several key areas.

Senior leadership commitment/strategic vision

Change proved difficult within schools where STEM does not feature among senior leaders' priorities or have their support. A lack of a strategic vision for STEM and clarity in terms of accountability for STEM were also identified as significant barriers.

People

Challenges associated with people included securing staff buy-in, developing staff capacity (confidence, knowledge and skills) and coping with staff turnover. Explicit and practical support from senior leaders can mitigate staff-related challenges, but the absence of support can compound them.

Resources

Resource shortfalls were consistently identified as a challenge in developing and delivering new work and new ways of working. The crucial resource was staff time: protected, off-timetable time was needed for key players (e.g. STEM leads) and, ultimately, for the wider staff body, for changes in culture and practice to be secured.

Processes

Several processes were identified as complicating and sometimes impeding STEM work, including timetabling or scheduling different activities (e.g. topics, lessons, examinations and departmental meetings).

Integration of STEM subjects

Relatively few challenges specific to the integration of STEM subjects were identified, and interviewees seemed relatively confident that these challenges could be surmounted or worked around.

Future plans and sustainability of STEM

Future delivery of STEM

At the end of year 2 of the STEM Initiative, two schools had spent the full grant received from the Wellcome Trust and six schools had funds remaining. In the short term, all six schools with funds remaining expect to use this resource to continue to deliver STEM activities. In the longer term, six schools expected to repeat or develop activities that had already been delivered; two of these schools also anticipated delivering additional activities.

Sustainability of STEM

In two schools, there were no longer-term plans to sustain STEM interdisciplinary activities. In the remaining six case study schools, there were indications that STEM interdisciplinary activities will be sustained beyond the lifetime of the STEM Initiative. This was particularly true in the three schools that had plans to deliver additional activities or included STEM in strategic or operational plans. Schemes of work had been a key focus of activity in these three schools.

Factors that support sustainability

The most frequently cited factors considered to strengthen the sustainability of interdisciplinary STEM activity are senior leadership support, the provision of time off-timetable for relevant teaching staff, funding for payments to staff or for supply cover, and the perception that STEM interdisciplinary activities can support a school's achievement of its attainment or improvement targets.

Conclusions

Overall, demonstrably impressive progress has been made by all eight schools throughout the two years of the Camden STEM Initiative, benefiting pupils, teachers and schools. There is substantial evidence of very effective collaborative and participatory practice in delivering STEM interdisciplinary activities. It is hoped that other schools will benefit from the two key elements identified as enabling interdisciplinary STEM activity. The first element is a commitment to STEM throughout the school – including in its organisational structure, staffing and school

development plan. The second main element of successful interdisciplinary STEM activity is that it is delivered through a variety of different activities and resources, some requiring a low level of buy-in and commitment (which can be used to initiate change) and some requiring greater levels of organisation – from the use of logos on PowerPoints that indicate to pupils when they are using a skill that will be applicable in other STEM subjects to the use of external experts and rewriting schemes of work.

In conclusion, a substantial amount of impressive and impactful interdisciplinary STEM activity has been delivered through the STEM Initiative. Every school has developed and progressed interdisciplinary STEM activity and can evidence achievements in this respect. Furthermore, there are reasonable and, in some cases very strong, indications that six of the eight schools will sustain STEM activities beyond the lifetime of the STEM Initiative.

1. Introduction and methodology

1.1 The Wellcome Trust Camden STEM Initiative

This report presents the findings of an evaluation of the Wellcome Trust's Camden science, technology, engineering and mathematics (STEM) Initiative (the STEM Initiative), which focused on supporting interdisciplinary projects spanning science, D&T and mathematics. In 2008, the Wellcome Trust commissioned a baseline study of such interdisciplinary activity in Camden secondary schools, which included gathering information from ten schools. The study found that:

- schools varied in their provision of science, D&T and mathematics interdisciplinary activities
- teachers struggled to know what activities to choose and they sometimes lacked the capacity to turn their choices into reality
- some activities in these subject areas focused on gifted and talented pupils and did not involve less able or less motivated pupils
- external providers of STEM expertise and activities found it difficult to communicate with schools effectively.

After the study, the Wellcome Trust convened a conference to bring together teachers of these three subjects in Camden secondary schools, as well as Local Authority representatives and STEM deliverers. Delegates were encouraged to consider how science, D&T and mathematics might be delivered in a more cohesive way within their schools. Schools were then invited to put in a proposal to deliver a two-year project, and eight schools were awarded up to £10 000 to enable the relevant departments to work together.

Projects spanned the two academic years 2009/10 and 2010/11, with most schools starting planning and delivery in the spring and summer term of 2009. Two key delivery models were used:

- the development and piloting of new schemes of work
- the development and delivery of enhancement and enrichment activities (e.g. a themed day or a series of themed days, a dedicated STEM week, after-

school STEM Clubs, visits out of school, or in-school visits from STEM Ambassadors).

The schools that focused their energies on devising new schemes of work often also delivered STEM enhancement and enrichment activities.

1.2 Understanding interdisciplinary STEM activity

In the context of this report, **what we mean by 'interdisciplinary STEM activity' is**:

> *collaborative working, typically between science, D&T and mathematics departments or teachers, within schools to deliver schemes of work, lessons, and enhancement and enrichment activities with the aim of more closely relating the teaching of STEM subjects, highlighting the links between them and showing how STEM subjects are closely connected in the 'real' world and employment.*

Although we use the term 'STEM', D&T has been more prominent in the projects than engineering, which has tended to be most evident within STEM clubs and specific enhancement and enrichment activities.

The key positive impacts of interdisciplinary STEM activity on students are:

- an increased engagement in STEM subjects
- a greater understanding of the importance of STEM subjects for further STEM study and careers
- an increased interest in pursuing STEM subjects and careers further.

Note that a focus on STEM interdisciplinary activities may improve STEM attainment and progression through pupils' increased motivation and engagement.[1] These benefits can help to convince senior school leaders to embrace STEM interdisciplinary learning, and their support is necessary for this approach to develop and thrive.

[1] NFER. 2009. Evaluation of the 2008-9 DCSF-funded Specialist Schools and Academies Trust STEM Pathfinder Programme. www.nfer.ac.uk/nfer/publications/PEV01/PEV01.pdf
Kuyper H et al. Motivation, meta-cognition and self-regulation as predictors of long-term educational attainment. Educational Research and Evaluation 2000;6:181–205.
Simpkins S et al. Math and science motivation: a longitudinal examination of the links between choices and beliefs. Developmental Psychology 2006;42:70–83.

1.3 The evaluation

The Wellcome Trust commissioned the National Foundation for Educational Research (NFER) to carry out the evaluation of the Camden STEM Initiative. This is the final report of the evaluation, with an interim report having been completed in September 2010.

1.3.1 Aim of the evaluation

The aim of the evaluation was to provide a high-quality evidence base to inform future programmes. The focus was on identifying practical transferable learning and examples of good practice that demonstrated ways in which interdisciplinary approaches might improve the experience, engagement and achievement of young people in STEM disciplines.

1.3.2 Methodology

A qualitative methodology was used, including case studies of participating schools at two points to capture in-depth data on their activities and to identify: good practice; challenges and barriers to STEM working; outcomes for pupils, teachers and schools; and issues relating to the long-term sustainability of the work.[2]

This report presents the findings from the case study visits for all of the eight schools involved in the STEM Initiative. Data were collected between June and October 2010 and again between May and September 2011. Case study visits included, as appropriate to each school, consultations with: a senior leader and/or the headteacher; STEM teachers responsible for leading and delivering the project (referred to as consultees when quoted); and pupils who had taken part. Where possible and appropriate, activities and lessons were observed. These focused on a

[2] Within the report, all quotations from teachers and senior leaders have been anonymised so that consultees cannot be recognised. In most cases, the text refers to quotations coming from 'consultees', which includes both teachers and senior leaders. Where pupil quotations have been included, the year group and school case study number have been added to show that comments have come from pupils across different year groups and from several schools. In the section on pupil outcomes, where teacher and senior leader quotations have been included, these have been differentiated from the pupil ones by adding either 'teacher consultee' or 'senior leader consultee' after the quotation. This approach has been taken to ensure that no individual pupil or staff member can be identified by any quotations.

range of themes delivered through different types of activity, including health and fitness, a science exhibition, constructing an aeroplane, building structures using a dowel and rubber band, and a clown- and juggling-inspired science presentation. Activities involved pupils from across Key Stages 3 and 4, and some were open to whole year groups and others were targeted at particular groups (e.g. pupils taking technology, or gifted and talented pupils).

In addition, a telephone interview in the first year of the evaluation was conducted with the Camden secondary science consultant who has been providing support to schools in the planning and delivery of their projects.

1.3.3 Audience

This report will be of interest to educationalists, education researchers, policy makers, and providers of STEM enhancement and enrichment activities, including outreach and widening participation staff within universities and education liaison officers within professional bodies and learned institutions.

It will be of interest to policymakers with a brief relating to school improvement and raising standards, raising participation post-16 and, in particular, those focusing on STEM subjects.

In relation to schools, it will be of interest to headteachers and senior leaders, heads of STEM departments, teachers of STEM subjects, Key Stage 3 and 4 Coordinators, staff in other subject departments responsible for organising enhancement and enrichment activities, Local Authority advisers, and parents.

2. Background to the Camden schools and their projects

2.1 Background to the eight Camden schools

Table 2.1 gives background data for the eight participating schools, in terms of their type, some characteristics of their intake and attainment levels. The types of schools varied widely and included mixed and single sex, comprehensive and special, with varied specialisms. The percentage of pupils eligible for free school meals, a measure of socioeconomic status, ranged from 17 to 69 per cent, and the percentage of young people identified as having special educational needs (including those at school action level and more complex needs) ranged from 8 to 50 per cent in the seven mainstream participating schools. The standard measure of attainment, five GCSEs at grades A* to C including English and mathematics, ranged from 37 to 76 per cent across the seven mainstream schools, against a national average of 55 per cent.

Table 2.1. Characteristics of the eight Camden schools involved in the STEM Initiative

	School type	Specialism	Age range	Number on roll, 2010	% SEN (Statement or School Action Plus, 2010)	% SEN (School Action, 2010)	% eligible for free school meals, 2009	% achieving five GCSE A*–C inc English and maths 2010 (2009)	% achiev two GCSE C in scie 2010 (20
Acland Burghley	Comprehensive, mixed	Arts	11–18	1250	11	11	22	51 (57)	42 (45
The Camden School for Girls	Comprehensive, girls	Music	girls 11–18 boys 16–18	1014	5	14	17	74 (73)	79 (69
Chalcot	Special, boys	Severe and complex ESBD[3]	11–16	46	Unknown	Unknown	49	-	-
Hampstead	Comprehensive, mixed	Technology	11–18	1290	7	18	35	54 (51)	58 (63
Haverstock	Comprehensive, mixed	Business and enterprise	11–18	1262	22	28	54	37 (38)	50 (47
La Sainte Union	Comprehensive, girls	Science with mathematics	girls 11–18 boys 16–18	1217	5	3	18	76 (75)	66 (68
Maria Fidelis	Catholic convent, girls	Humanities and the Arts	11–18	824	9	12	37	47 (44)	33 (20
South Camden Community School	Comprehensive, mixed	Visual and Performing Arts	11–18	898	14	17	69	38 (37)	36 (25
Camden Local Authority average								53 (51)	53 (48
National (English) average, state-funded schools only								55 (51)	62 (54

[3] Emotional, social and behavioural difficulties.

2.2 The schools' STEM baseline positions

Before becoming involved in the Wellcome Trust project, interdisciplinary STEM activity was not a priority for schools, but some impressive work on STEM was being led by individual teachers or departments. More detail on the STEM baseline positions of the eight schools is provided below.

2.2.1 STEM profile

Before the start of the project, developing links between the STEM subjects had not been prioritised by senior management in any of the eight schools (e.g. in the School Improvement Plan) nor was it explicitly supported. No school had a dedicated STEM Coordinator or had allocated time in the timetable to support cross-departmental working.

Nevertheless, interdisciplinary STEM activity was taking place, led by individual, enthusiastic teachers, and this work was valued, but not driven, by senior staff. As one consultee commented: "The school's work on STEM up until now has been primarily driven from the STEM departments as opposed to top-down, although senior managers fully support and encourage it."

The fact that there were already enthusiastic teachers within STEM departments keen to drive STEM interdisciplinary activities was seen as positive. However, for the work to be more fully rolled out across year groups, and for it to be sustained in the longer term, it was thought that senior leader commitment and a high-level prioritisation of interdisciplinary STEM activity were needed. Given this, a balance between a bottom-up and a top-down approach was required.

Although undertaking interdisciplinary STEM activity was not always a whole-school priority, raising participation in the individual STEM subjects sometimes was. In one school, a priority within the departmental improvement plans for science and mathematics was to improve uptake at Key Stage 5 and a priority in the technology departmental improvement plan was to improve uptake at Key Stages 4 and 5.

The reasons given for interdisciplinary STEM activity not being a priority tended to relate to the many competing priorities for schools and a lack of time and funding (see section 6 for further details on the challenges and barriers to project implementation).

> *Teachers had the desire to work across departments but the time and money weren't available.*

> *Developing links between STEM subjects was more on a 'wishlist' than being a priority. It's one of those things that you know would be good to do, but it can become overcrowded by other competing priorities…Budget constraints have also worked against us being able to implement any developments in cross-departmental working.*

Where links were already in existence, they tended to be between science and mathematics or science and technology.

> *Some science and mathematics teachers would check what was being taught in the other subject and some were enthusiastic about the potential [of cross-departmental working], but teachers generally had very little knowledge of what was taught and when in other subjects.*

2.2.2 Working across STEM departments

Before the Wellcome Trust funding, STEM teachers generally knew the staff within other STEM departments but collaboration between staff across STEM departments either did not occur or tended to be ad hoc.

In schools where close links had been forged between particular staff within departments, this tended to be as a result of a specific project being developed or delivered, individual staff members' enthusiasm to work with other departments, or prior friendships. It was also related to the school being keen on innovation and cross-curricular working in general.

Three schools had already started to identify how the teaching of STEM subjects might be more closely linked. In one of these, initial work identified crossover between the technology and science curricula and looked for opportunities for joint working, but this was not seen as a 'formal' process. In another school, cross-curricular working was taking place across several departments and links had already been forged between science and mathematics teachers, with staff looking at how they could relate their

teaching more. In the third school, previous cross-curricular links were evident between science and mathematics, but they were not consistent.

In the five remaining schools, teachers' awareness of the curricula in the STEM subjects that they did not teach was generally low (although this varied by teacher) and the tendency was for the subjects to be taught separately: 'the curricula of different subjects are disparate'. However, among science and technology teachers, there was often an awareness of what was taught (or was likely to be taught) in mathematics but no awareness of how and when, and there was no staff time to make the teaching consistent. One consultee commented that some topics, such as graphs, were taught in all of the STEM subjects but tended to be taught in different ways in different subjects with no reference between them. Two of these five schools were either developing or had delivered a project that spanned more than one STEM department. However, these were isolated projects not linked to a review of the curriculum or the interdisciplinary teaching of STEM subjects. One of these schools had delivered a project via the science and D&T department related to designing solar-powered cars, and another school was developing a project with Hewlett-Packard combining mathematics and technology. Other schools had undertaken ad-hoc STEM-focused enhancement and enrichment activities. As one consultee commented, ad-hoc trips and activities that focused on STEM were 'welcomed with open arms' but were not part of a particular plan. Another consultee commented: 'STEM activities were generally ad hoc in nature. They were selected mainly on the basis of convenience.' Two of the schools had used STEM Ambassadors previously, and one of these schools had been a STEM Pathfinder School in which collaboration between the STEM departments had already started in relation to enrichment work. Two schools already ran a science club but none ran a broader STEM club or an engineering or technology club. Schools had also drawn on a range of other STEM or science-related enrichment opportunities such as the 'I'm a Scientist' project', the Institute of Education Associates Scheme, and gifted and talented STEM days at universities. However, only one school had taken advantage of STEM Continuing Professional Development (CPD) opportunities at the Science Learning Centre.

An area of strength for all schools was teachers' ability to teach the STEM subjects with a real-life focus, which, in science, had been driven and supported by the 'How Science Works' focus of the curriculum. Three schools were also regularly bringing examples of careers into lessons and/or using STEM Ambassadors to support this.

Across the eight schools, then, some good work had already started in STEM, but no schools had started to formally review and change schemes of work to ensure that links between the different curricula were embedded in teaching.

2.2.3 Confidence of staff in undertaking interdisciplinary work

In general, there were mixed levels of confidence among staff in delivering interdisciplinary projects and a need for more guidance on this area: compare 'three or four teachers embrace the idea and are enthused, and there will be others who are out of their comfort zone' and 'staff are generally not confident undertaking cross-curricular work across departments'. However, in one school there was a previous culture of departments across the school working together and more openness to (and confidence in) delivering cross-curricular projects, and in another teachers were open to change and 'thinking outside the box'.

2.3 The schools' Wellcome Trust project plans

The aims of most projects were to increase engagement and interest in STEM subjects in the hope that this would increase aspirations and participation in post-16 STEM study and careers, as well as lead to raised attainment. Where the focus was on enhancement and enrichment activities, increased engagement would be achieved through providing fun and 'real world' experiences. In addition, the aim was for the linking of the STEM subjects in curriculum delivery to lead to an increased understanding of how the subjects are linked in the real world and the development of transferable skills, including skills for employment. It was also intended that improving the links between the teaching of STEM subjects would lead to increased consistency in teaching topics such as graphs and reduce repetition. Schools

also hoped that involvement in the project would enable them to learn from other schools and open doors to other STEM opportunities.

3 Project delivery and progress

This section explores the delivery and progress of the eight STEM projects over the two years of the Camden STEM Initiative.

3.1 How have projects been led and managed?

Schools varied in how they led and managed their projects, and some changes to the leadership and management of delivery have taken place over the course of the second year (sections 5 and 6 explore what approaches are working well and what challenges have been faced, in relation to leadership, management and staffing). Three schools chose to use a small amount of the funding for staff responsibility payments. Others used some of the funding to pay for supply cover to support the planning process. The different arrangements for managing and leading the projects are detailed below.

- Three staff from across STEM were designated as the STEM leads, with the science teacher taking overall responsibility. A proportion of the funding was designated for a STEM Coordinator position, split between these three teachers.
- A science teacher, the undesignated STEM Coordinator for the project, led the project with one other science teacher. Previously, in year one, there were approximately seven other staff within science and mathematics involved with the project.
- Three staff were appointed as leads across STEM with one of these taking on the role as the overall STEM Coordinator. Each lead received a responsibility payment.
- A science and technology teacher jointly delivered the project.
- A science teacher, who was responsible for enrichment before the start of the STEM Initiative, took on the role of STEM lead within the school.
- A technology teacher took on the role of overall STEM Coordinator, working with two STEM Champions from mathematics and science. Staff received responsibility payments and, in the second year, they received time on-timetable to deliver the project.

- A science and mathematics teacher jointly led the project and, in the second year, they were supported by a cross-departmental STEM working group including teachers from all STEM subjects.
- A science teacher led the STEM work and drew on the support of other staff within the science and mathematics departments where possible.

Only two schools gave staff regular time off-timetable to plan activities. In one of these schools, three staff were given one hour every two weeks to meet and plan. In the other, the regular planning time allocated to the Key Stage 4 curriculum was used. In another school, staff were allowed to use some of their INSET time to attend cross-departmental STEM planning meetings. Some projects aimed to involve all staff across the STEM departments, whereas others chose to deliver the activities through a small team. During the first year of the project, in most cases, staff in all three STEM departments were involved in the project, but in the second year there was a shift to the work primarily being undertaken by science and mathematics – or science and technology – teachers. This was particularly the case in schools where key teachers left early in the second year.

In most cases, there was little intervention from senior leaders and designated staff were delegated the responsibility for leading the school's STEM work.

3.2 What has been delivered?

The Wellcome Trust gave schools the freedom to devise a project that fitted their current stage of development in relation to STEM and individual needs. As a result, schools delivered a wide range of projects with different scope and foci. The money provided was used to pay for:

- additional responsibility payments for staff
- staff to run after-school activities
- supply cover to enable staff to work together to plan activities[4]

[4] The cost of which is approximately £190–£200 per day.

- new resources, materials and equipment (e.g. data loggers, medical equipment, materials to build a wind turbine and solar heating panels)
- professional development for teachers
- pupil trips, speakers, facilitators and so on.

Three schools used the entire funding to buy resources and equipment, whereas others divided it up across a range of areas. The projects that schools delivered have focused on either planning and delivering enrichment activities (five schools) or revising schemes of work to draw out the links between the STEM subjects. Three schools combined these two activities.

A summary of the progress made by each school's project over the two-year period of the STEM Initiative, as reported by the schools,[5] is presented in Table 3.1 below, and more detail is given in Appendix 1.

Schools' progress in the first year was very good given that STEM had not previously been explicitly supported. All schools have continued to successfully deliver a wide range of STEM activities in the second year of the project, targeted mostly at Key Stage 3 pupils, although there have been some challenges in delivering all the activities originally planned.

In some cases, the delivery of activities has been postponed to 2011/12 to give more time for the preparatory and planning work. This has often applied to projects in which senior leadership support has lessened or other school priorities have had to take precedence. However, all schools have delivered, or plan to deliver, all they originally intended, albeit sometimes with slight changes. Only one of the schools is yet to agree these changes.

The schools that focused on delivering enrichment activities generally delivered less than they anticipated in their initial plans, particularly in the second year (two were affected by a key teacher leaving). These schools delivered some smaller, one-off enrichment activities in year 2, and/or continued some of the activities they delivered in the first year as opposed to embarking on new activities. For example, in three schools some activity concentrated on one or two STEM subjects, rather than being fully interdisciplinary (in one of these, a key teacher left early in the second year).

[5] Schools were invited to review the descriptions of what they delivered as part of the Initiative.

In comparison, those schools that focused more on revising their schemes of work and embedding STEM links in lessons delivered almost everything they planned to in their initial project plans and in some cases more. These schools, to varying degrees, revised, piloted and rolled out new schemes of work for different year groups within Key Stage 3, along with delivering a range of enrichment activities.

Table 3.1. Summary of schools' progress

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
Acland Burghley, 11–18 comprehensive with arts specialism			
Olympics-themed day for Key Stage 3 pupils.	Delivered for 80 Year 8 pupils.	Extension to original plan – the school also delivered a 'Patterns in Nature' day for Year 7 pupils.	Further STEM activities planned.
Science and engineering club for Key Stage 3 and Key Stage 4 pupils.		STEM Club established. Organised a trip to the Science Museum as part of the STEM Club Science Day for Year 7 pupils.	
The development of a series of cross-curricular units across science, D&T and mathematics about smart materials.	Development of new schemes of work for Year 9 pupils with the aim of making links between the three subjects but also to support the development of skills such as personal learning, enquiry, collaboration and self-management.		
Science and technology fair, including project-based work and access to individuals with STEM careers.	Adapted from original plan – STEM Challenge Day for gifted and talented Year 9 pupils.		
Payment of a STEM coordinator.	Not yet taken forward.	Not yet taken forward.	
Bursary for a sixth form student studying STEM.	Not yet taken forward.	Not yet taken forward.	
STEM INSET for teachers.	Science teacher who coordinated the school's STEM work attended training at the Science Learning Centre, on setting up a STEM Club, and an INSET day was		

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
	delivered to teachers in the technology department.		
Camden School for Girls, 11–18 girls' school with music specialism			
Disease outbreak week for all pupils, covering a different theme every day (e.g. disease outbreak, health and fitness workshop, disease identification, vaccines, science fair) and involving representatives from a range of agencies such as the Health Protection Agency, Classroom Medics and higher education.	Delivered during National Science Week in July 2010. Activities for pupils included a science show, a physics lecture, a science fair and a visit to Wellcome Collection. Extension to original plan: - development of a science and art exhibition by Year 9 gifted and talented pupils in lessons - delivery of a talk to Year 8 pupils about medicine in Roman times by a Cambridge classics professor.		
Develop further cross-curricular collaboration from September 2010.		Science schemes of work were revised, taking account of any cross-curricular links with mathematics, and a range of scientific equipment was purchased, including data loggers and microscopes. Extension to original plan: - Year 9 science project and a Year 8 science-related art project, culminating in a	Set up an after-school Science Club, which will offer a range of activities to eventually include CREST awards. Deliver a workshop focused on engineering and technology to Year 8 pupils.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
		science fair exhibition at the end of the school year - a talk by a well-known scientist to all Year 7 and Year 8 pupils.	
STEM teachers to undertake professional development in relation to Key Stage 3 STEM subjects working together.	Not yet taken forward.	Not yet taken forward.	Establish links between pairs of teachers in science and mathematics to more closely coordinate the teaching of these subjects.
Chalcot, 11–16 school for boys with severe and complex social, emotional and behavioural difficulties			
To develop and pilot a STEM scheme of work based on producing useable heat and electric sources of energy for the school from working wind turbines and solar panels. Project to target Key Stage 3 and 4 pupils and include classroom experiments and building real-life working models to generate electricity.	The curriculum for Key Stage 4 pupils (both Years 10 and 11) was completely rewritten to ensure the integrated teaching of STEM subjects, including assessment towards the BTEC Applied Science Introductory Course (level 1) single award (for Year 11 pupils) and double award (for Year 10 pupils). Pupils' work related to alternative energies and included lessons focused on wind turbines, solar panels, building a weather station and using data logging equipment.		
Scheme of work to become permanent following any adjustments that are needed.		The curriculum continued to be taught. The STEM activities undertaken by	Continued delivery of the integrated curriculum to Key Stage 4 pupils and, when appropriate, to Key Stage 3 pupils.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
		pupils throughout the course of the 2010/11 school year included: conducting all the experimental laboratory work to develop materials to capture sunlight to heat water; completing all the Science Enhancement Programme practical investigation work on the wind turbines; and work on probability and data analysis in engineering as preparation for the set up of a weather station, as intended.	Pupils will progress to building a model for the hot water heating solar panel, complete the rest of the lessons and activities to finish building the life-size model wind turbine and conduct weather data collection using the newly installed weather data logger.
Two teachers attend professional development CPD related to alternative energies technologies (wind turbines and solar panels) at the Centre for Alternative Technologies (CAT).	Two teachers went on a full week course at CAT in Wales in August 2010 and attended a day's training at Edexcel.		
Hampstead School, 11–18 comprehensive with technology specialism			
Transform science week into STEM week in July 2010	Delivered a STEM week in the penultimate week of the summer term 2010. As part of this week, several visitors gave talks and demonstrations during the day and after school. These talks included a talk from a representative of the Department for Energy and Climate Change, a talk from a civil engineer and a talk about planets		Delivery of another STEM week, which is planned for the spring term 2012.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
	(which took place within a mobile planetarium).		
New schemes of work that link all of the STEM subjects for each year group.	Schemes of work that integrated mathematics, D&T and science were developed for Years 7, 8 and 9 (Key Stage 3).		
Greenpower competition for the 2010/11 school year.		Not yet taken forward.	The delivery of a STEM activity using the Greenpower project as a framework.
Set up a STEM Club in September 2010.		A weekly STEM Club was set up in which pupils undertook a variety of experiments to engage them in STEM.	Continuation of the STEM club. It is anticipated that activities delivered to BTEC Engineering Year 11 pupils (as part of the curriculum) could form the basis for further STEM Club activity for younger year groups.
Teachers will undertake professional development to support the setting up and delivery of the STEM Club, organising the Greenpower project and teaching other STEM subjects.	STEM teachers undertook CPD in June 2010, which was delivered by the Science Learning Centre, and reviewed work from the Nuffield STEM Futures Scheme, which was being released to schools in 2010/11.		
Haverstock School, 11–18 comprehensive with business and enterprise specialism			
Appoint three STEM leads across science, mathematics and D&T to start in September 2010 for three terms, with one of these being responsible for the overall	Three STEM leads across science, mathematics and D&T appointed to form the STEM team, with one overall coordinator.		

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
coordination of STEM within the school and managing the team.			
Identify STEM links between the science, mathematics and technology Key Stage 3 schemes of work, then plan and embed appropriate activities into these. Start with Year 7 and then move into the whole of Key Stage 3. All teachers across the STEM departments will be expected to deliver the new schemes of work and the leads and/or coordinators are to monitor and evaluate delivery and impact. First schemes of work will be delivered in summer 2010 and then adjusted and adapted as needed.	Developed an action plan focused on the identification of links between the STEM subjects in schemes of work for Year 7 pupils and used STEM homework exercises to make these links clearer. Extension to original plan: - action plan included the identification of gifted and talented pupils in STEM subjects to enable teachers to differentiate lessons, as well as to target these pupils for additional enrichment activities and at options evenings at transition points from Key Stage 3 to 5 - the delivery of a Year 7 competition - the set up of a folder on the network drive to share STEM resources among other staff.	Continued work on Year 7 schemes of work, mapped the curriculum content for Years 8 and 9 and wrote STEM objectives into schemes of work. As part of this, three STEM projects were delivered, comprising three separate sets of lessons delivered to Year 7, 8 and 9 pupils focusing on a rocket/propulsion project, constructing a bridge, and designing and building a solar car. Extension to original plan: - collation of further science exercises by the Lead STEM Coordinator so they could be repeated by another teacher - attendance of a group of gifted and talented Year 8 pupils at a climate change workshop, which enabled them to have a more hands-on experience of the theory they had been studying - activities related to progression, transition or careers in STEM were delivered to boost pupils' and parents' understanding of	Continued delivery of the homework activities developed as part of the revision of the schemes of work for Years 7, 8 and 9, and to repeat the rockets project as part of an after-school STEM Club.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
		STEM careers, around the time Year 8, 9 and 11 pupils were making their option choices - a STEM quiz was included in the school diary distributed at the start of the year and displays of STEM information were set up throughout the school.	
Each STEM Coordinator to attend termly STEM meetings and at least one day of training through the Science Learning Centre.	Adaption of original plan – not delivered to enable the STEM team to spend more time to collectively plan and deliver the action plan.		
La Sainte Union, 11–18 Catholic girls comprehensive school with a specialism in science with mathematics			
To deliver a project called 'Garden of Eden' to enthuse pupils about plants and their importance to our everyday lives and to increase their enjoyment of STEM subjects. Project to focus on Years 9 (who will lead), 8 and 10 and will include visits and lectures.	Delivered the 'Garden of Eden' project for Year 9 pupils, which taught them about the links between the STEM subjects through building geodesic domes using lightweight and recyclable materials. Pupils then compared the environmental conditions inside and outside the domes, analysed the data and drew conclusions about optimum growing conditions. Extension to original plan: - the school organised network events on STEM to which	Continued the Year 9 project, which was expanded, and a vegetable garden was developed for the pupils. Some of the learning from this project is currently being built into technology schemes of work.	Provision of a range of enrichment activities and events, including work with STEM Ambassadors and scientists coming in to give talks.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
	other Camden schools were invited.		
Year 8 to visit the new cocoon at the National History Museum, some of whom will write a feature on the cocoon or related topics on the front page of a newspaper during a visit to the Guardian Newsroom.	Happened as planned.		
Year 10 to take part in the Millennium Seed Bank 'Save our Seeds' project.	Happened as planned.	The Millennium Seed Bank project was exhibited at the Big Bang Fair by Year 11 pupils who had been awarded Silver CREST awards.	
Some pupils will attend 'The Talking Trees' Royal Institution Christmas lecture.	Happened as planned.		
The whole school will listen to trees using headphones, and tree identification workshops will be run.	Not yet taken forward.		Delivery of the 'Listening to Trees' activity, or another relevant activity such as a tree identification workshop.
The three teachers on the working party will attend relevant CPD.	Not yet taken forward.		
Maria Fidelis, 11–18 Catholic convent school with specialisms in humanities and the arts			
To deliver a project called 'Pupils Tackle Environmental Matters' from May to December 2010, focusing on their school rebuilding work as part of the Government's Building Schools for the Future programme.	Adaptation of original plan – the cancellation of the Building Schools for the Future programme meant that the school had to alter its plan, including the delivery of a STEM day in the spring term for the whole of Year 8 and a STEM	Additional to original plan: - STEM Coordinator and the Head of Mathematics set up a STEM cross-curricular group of staff who worked together to develop activities around the theme of 'sustainability	The conservation area will be used to develop further STEM activities (such as studying insects, measuring populations and life cycles, and botany) and write this material into schemes of work.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
Year 8 pupils to look at features of good building design and efficient methods for running schools, with a focus on energy conservation and the benefits of using particular materials. Build aspects of the programme into future curriculum plans for Year 8 pupils.	activities week in the summer term. A new scheme of work was written for pupils to follow before this STEM week, focusing on water purification, keeping warm and providing power. In addition, lessons on sustainability were delivered to a cohort of Year 7 pupils.	and environment' - cross-curricular group built in STEM links to science for Year 9 pupils and developed an area of garden into a conservation area, which is being used as the context for delivering several STEM project activities for pupils in Year 7 and Year 8.	
Pupils to attend workshops and visits.	A group of gifted and talented Year 8 pupils attended the Big Bang Fair.		
CPD for teachers within the working party will be provided by the Smallpeice Trust and all staff will be made aware of the work through internal INSET.	The mathematics and science STEM lead teachers attended a lecture at St Mary's University College and one at Hertfordshire University on sustainability and futures thinking.	Adaptation of original plan - raised awareness of STEM through the set up of a STEM cross-curricular group, which used some INSET time for its meetings (see above).	
South Camden Community School, 11–18 comprehensive school with an arts specialism in visual and performing arts			
To recruit a STEM coordinator in D&T, as well as two subject champions in mathematics and science to form the working party.	Happened as planned. This STEM team explored the best way to deliver the project by reviewing existing schemes of work and exploring opportunities to run collaborative after-school clubs. STEM was included as a regular		South Camden Community School plans to train a group of Key Stage 4 and Key Stage 5 pupils as STEM Champions; they will work towards CREST awards by running the STEM after-school clubs for Key Stage 3 pupils.

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
	agenda item at departmental meetings in all of the three subjects.		
To embed STEM within schemes of work across the science, mathematics and D&T departments. This will be piloted with Year 8.	Scheme of work was rewritten for the Year 7 D&T curriculum, focusing on embedding links between D&T, science and mathematics. Additional to original plan: work began on revising the Year 8 curriculum in a similar way, and a range of STEM activities were delivered to pupils in Years 7 to 10, including: - a Smallpeice Trust activity in which pupils built an aeroplane - attendance at the Big Bang Fair in London - a session on food hygiene and product development involving a STEM Ambassador - building and racing radio race cars as part of the school's creativity week.	Year 7 D&T schemes of work were finalised and prepared for roll out in 2011/12. Year 8 D&T scheme of work was piloted for one carousel (group) and mathematics and science started revising their respective schemes of work. Additional to original plan: - a STEM creativity week, for Years 7 to 10, involving the exploration of STEM through kite building and a flying competition - repeated delivery of the radio race car activity - a young engineers' day for Key Stage 3 - attendance at an event at the Institute of Mechanical Engineers followed by a school assembly taken by the pupils who had been to the event - a programme of activity for National Science and Engineering Week	

Original project plans as outlined in Wellcome Trust applications (2009)	Activities delivered in year 1 (2009/10)	Activities delivered in year 2 (2010/11)	Future plans
		- a group of Year 8 girls participating in a 'Robo Girls' event.	
After-school club for Key Stage 3 and 4 pupils (including hard to reach and gifted and talented pupils).	An after-school STEM Club was set up in the autumn term of 2010.		
Several CPD opportunities will be planned, initially for the working party (possibly through the Science Learning Centre and SSAT and at the Design Museum). Learning will then be filtered down to other staff through departmental meetings.	The key STEM Coordinator attended a course at the National Science Learning Centre on Engineering through the Curriculum, and the Science Champion attended CPD at the CERN centre in Switzerland (also through the Science Learning Centre).		

4 Outcomes

Section four describes the range of outcomes that have been realised over the STEM Initiative. This includes outcomes for pupils, teachers and schools. It also touches on the sustainability of outcomes and the extent to which they would have occurred in the absence of the funding.

4.1 Overview of outcomes of interdisciplinary STEM activity

A variety of different outcomes of interdisciplinary STEM activity were reported by schools, as presented in Figure 4.1 and discussed in more depth in the following sections.

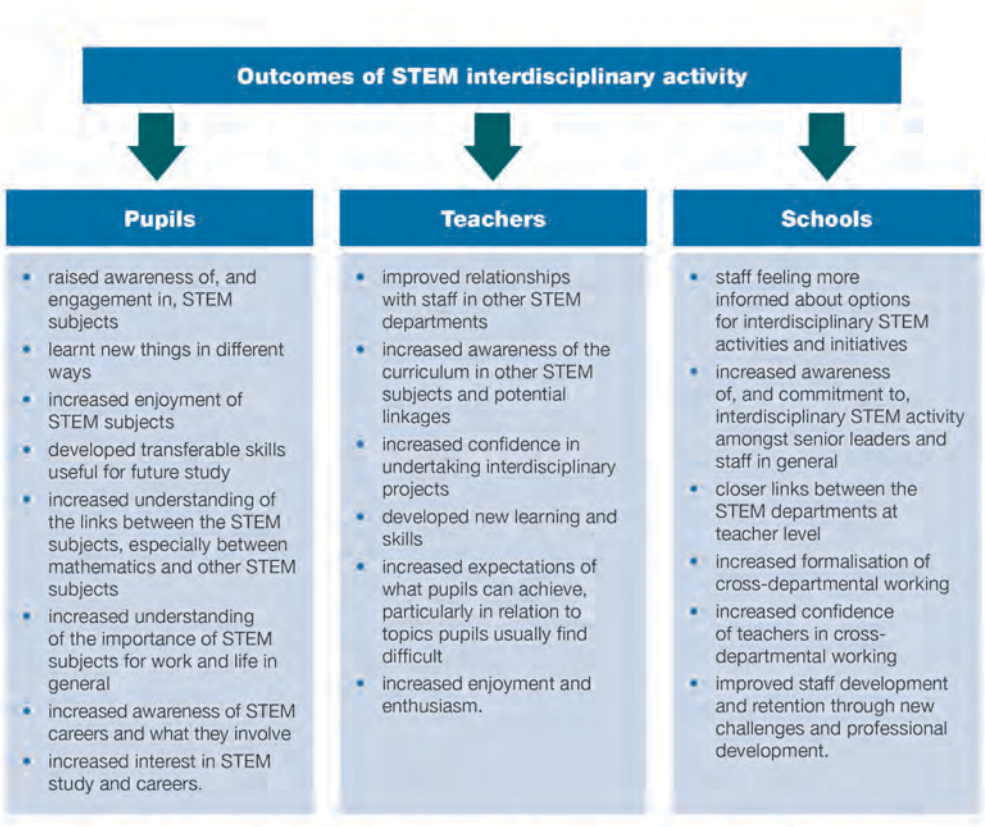

Fig. 4.1 Overview of the outcomes of interdisciplinary STEM activity

4.2 Outcomes for pupils

At the time of writing, the outcomes on pupils of schools' activities around schemes of work were only just emerging – as one teacher commented, 'it's quite early days in terms of seeing impacts from the changed schemes of work'. Consultation with pupils in these schools was not appropriate. However, staff have, in a few cases, reported impacts that are starting to arise as a result of delivering new schemes of work, and these have been highlighted where appropriate.

By contrast, the outcomes for pupils of STEM enhancement and enrichment were much more evident and therefore dominate this section. Most schools have chosen to involve whole year groups in their STEM enhancement and enrichment activities, but some targeted gifted and talented pupils to provide them with extra development and challenge. Much of the STEM activity has been focused on pupils in Key Stage 3 due to the constraints at Key Stage 4. Several teachers commented that focusing activities on Key Stage 3 is likely to have the most impact as pupils in this stage are usually more open to influence than pupils at Key Stage 4, who tend to be more fixed in their ideas of what they want to do in the future.

It is worth noting that if STEM enhancement and enrichment activities with particular pupil groups are not built upon and sustained over the longer term, the initial benefits detailed in this section are likely to wane. For impacts to be sustained, it has been suggested that pupils need to be exposed to enhancement and enrichment activities on an ongoing basis; for example, at least once a term. Where schools have focused on adapting schemes of work, outcomes will more naturally be sustained over time:

> *Big events, they look good…but they don't really live that long in the consciousness, which is why we focused on the schemes of work. I think that was the thing that happened to us, the more we looked at it, the more we realised that actually if we're going to have any real impact to this year it was going to be about leaving some sort of legacy in the schemes of work...it means that next year the exact*

same lessons can be done, and so there is some sustainability there. (Teacher consultee)

4.2.1 Raised awareness of, and engagement with, STEM

It is evident that **projects have raised the awareness of pupils as to what STEM is, and enhancement and enrichment activities have begun to increase pupils' engagement with these subjects**:

> *The focus so far has been on enrichment activities, and it has started to raise the profile [of STEM] for students…It has been great for student engagement. There has been very positive feedback on the in-school and the after-school activities.* (Teacher consultee)

> *It has generated a lot more interest in STEM subjects. Pupils have been talking about what they have been enjoying in science and maths.* (Teacher consultee)

> *In little ways you can tell that students' perceptions and understanding of STEM is changing. For example, this time around everybody knew what a STEM day was.* (Teacher consultee)

> *A teacher came back yesterday and said she'd never seen students so engaged with what they were doing, so proud of what they were doing.* (Senior leader consultee)

When asked whether they would be interested in undertaking more interdisciplinary and practical STEM activities, pupils invariably agreed enthusiastically. In addition, where they had been working towards an award, they were keen to proceed to the next level:

> *To do the next level of CREST Award [the silver level] it would have to look similar to the solar car project, working in teams, more practical work as it's more engaging.* (Year 9 pupil, case study 3)

Pupils also agreed that they would encourage other pupils to become involved in these types of activities:

I'd tell them just go ahead and do it because it is fun and you get to do more things compared to sitting down. (Year 8 pupil, case study 3)

It's a great opportunity and at the end you feel like you actually achieved something, and then you get awarded like the CREST Awards. (Year 9 pupil, case study 3)

4.2.2 Learning new things in different ways

Pupils have enjoyed learning new things and learning in different ways and/or environments. They have learned about new topics not previously explored in school and have a better understanding of the application of STEM subjects in the real world:

You learn more about different types of science. We learned about different types of diseases and how you cure them. It opened our eyes. (Year 10 pupil, case study 7)

I've learned new stuff and have more idea about how science would work in real life. (Year 8 pupil, case study 1)

They also learned about rapid modelling techniques and printed designs on shirts and mugs. It expanded their capabilities with new techniques. (Teacher consultee)

We learned how quickly disease can spread. (Year 13 pupil, case study 7)

I've learned something new. I didn't know about renewable fuels before. (Year 8 pupil, case study 1)

We learned how to measure heart rate and blood pressure and about the roles of doctors and nurses. (Year 13 pupil, case study 7)

It was good to put learning into context and it was a good way of applying what we were taught. (Year 13 pupil, case study 7)

We learned about things that we would not normally learn about in school. There was more technology that we don't have in school. (Year 11 pupil, case study 6)

It made me more aware of what happens around you and the problems that can arise in other countries. (Year 11 pupil, case study 6)

They also benefited from attending workshops delivered by both teachers and outside professionals, and visiting careers events and STEM-related organisations and museums outside of school:

> *You learn more in a different environment. It's boring if you are in the same environment all the time.* (Year 11 pupil, case study 6)

> *The success has been that pupils have worked in a different way, which has been different to the normal style of maths. They have needed to do more active learning of maths outside of the classroom. They flew the rockets outside and enjoyed being out of their normal classroom.* (Teacher consultee)

In addition, two senior leaders have noted that the out-of-school enhancement and enrichment activities have provided less affluent pupils with opportunities that they would not normally be exposed to:

> *Less affluent pupils have been given opportunities to have access to different places.* (Senior leader consultee)

> *These types of experiences are very necessary for the pupils at our school. There are considerable levels of social disadvantage among pupils and they really value the opportunities that out of school trips provide.* (Senior leader consultee)

Pupils particularly valued and benefited from learning in a different and more interactive way. This has included solving problems as a group, gaining practical experience of designing and making models, researching, and preparing material for a group presentation:

> *[The STEM activities] are different to normal lessons and they are getting real world hands-on experience and applications. They are thinking about things in different ways and are doing more independent thinking. They are also developing transferable skills such as presentation skills.* (Teacher consultee)

> *You can interact with things. It helps you understand it more…we all learn more through interactive things.* (Year 9 pupil, case study 6)

Pupils have also had to use the knowledge that they have acquired in their STEM lessons to solve problems involving all of the three subjects:

> *You need to think about the whole creation process and use what you know from the different subjects* (Year 8 pupil, case study 1).

4.2.3 Increased enjoyment of STEM subjects

Pupils found the activities fun, and **their engagement with and enjoyment of learning STEM subjects has increased** as a result of their involvement in contextualised 'real world', practical activities and the freedom they have been given to use their own initiative, be creative and explore their ideas. The activities have also given them a real sense of achievement:

> *We were making flying things yesterday, which involved D&T and science. I enjoyed it. It was fun and practical.* (Year 8 pupil, case study 4)

> *I could explain [the practical] to visitors next time. I enjoyed the exercise. I enjoy doing practicals and I didn't do many at the school I was at before.* (Year 11 pupil, case study 2)

> *It's just like a fun activity…it's more fun to do practicals.* (Year 10 pupil, case study 7)

> *You can get to do stuff and get involved. I've really improved in science.* (Year 8 pupil, case study 7)

> *You have to use your own initiative rather than the teacher telling you what to do, which is better.* (Year 9 pupil, case study 8)

> *It's really good and so much more fun and interesting than lessons. In lessons we don't get any chance to express ideas as everything is set. This is good for our education. It's an opportunity to explore ideas …Today is one big thought experiment…In lessons you are restricted.* (Year 8 pupil, case study 1)

> *We did a lot more experiments than we would do in normal lessons. We had more time and it was more complicated.* (Year 11 pupil, case study 6).

In addition, several consultees have noted the positive impact on pupils of teaching mathematics in a more practical way:

> *We should do more of it in maths…more games and exciting activities. It's easier to understand if you see something.* (Year 8 pupil, case study 7)

> *Being able to point pupils toward the practical uses for maths (i.e. within science and technology) has been one of the best benefits. Because so often they say 'When are we ever going to have to use this?'* (Teacher consultee)

4.2.4 Development of transferable skills

Pupils have commented that **they have developed a range of transferable skills, which will be useful to them in future study and employment**. These skills include communication, teamwork, problem solving, planning and organisation, research, and time management. They have also learned that it is important to continually review and improve their work. The following quotes illustrate the range of skills pupils have developed:

Communication

You learn how to talk to different people. (Year 9 pupil, case study 8)

Teamwork

It was good working with other people. You had to use teamwork more than you would if you were with people you already got on with. (Year 8 pupil, case study 1)

You had to be organised. You do that job, I'll do this job. Someone had to take charge but you weren't bossed about. (Year 8 pupil, case study 1)

It's working as a team, developing your ideas and new skills. (Year 9 pupil, case study 3)

You're involved with other people and it makes it easier and it's just nicer to work in a team with other people to help you do things; it makes it more fun as well. (Year 8 pupil, case study 3)

Using their initiative

You had to use your own initiative rather than the teacher telling you what to do. (Year 9 pupil, case study 8)

I'd say I enjoyed it because when you're in control you feel like you can do it yourself. (Year 8 pupil, case study 3)

Research skills

When I get homework I'll now know more about how to research as I've had some initial guidance. (Year 8 pupil, case study 1)

Working to deadlines

We also gained quite a bit about working really, learning that if you have a deadline you can't go past it, realising that you can't complete it the day after. If you weren't finished then your piece of work was not very good. (Year 8 pupil, case study 1)

Continuous review and improvement

I gained quite a lot. To make our design good, my group were changing designs to improve it as we were going along. You always had to keep an eye out for how to redesign to make it better. (Year 8 pupil, case study 1)

Some pupils also commented on the benefits of gaining an award (e.g. the CREST Award) as a result of STEM activities:

If you've done it they gave you a CREST Award, and we thought that'd be useful in the future and it sounded quite fun. (Year 9 pupil, case study 3)

*I thought it'd be useful for your CV. (*Year 9 pupil, case study 3)

4.2.5 Increased understanding of the links between the STEM subjects

Wellcome Trust-funded activities led to **an increased awareness among pupils of the connections between STEM subjects and the fact that they are linked together in the world of work and within STEM careers**:

You don't realise there are such strong links between the subjects. (Year 9 pupil, case study 8)

We do similar things in technology and science but [teachers] don't usually make it clear what is similar and we do things at different times. It needs to be made more clear. (Year 8 pupil, case study 1)

Links are important. It's too complicated to study subjects together but if teachers make the links then it's clear what bits are relevant…the benefits are that you realise and know what bits are relevant and what you need for careers. (Year 8 pupil, case study 1)

In science we have bar graphs and line graphs and we do these in maths as well. Yes, the teachers call the graphs the same things. (Year 8 pupil, case study 3)

It's good because as we get older we've been working on subjects separately so we have to combine them when we reach sixth form. It gives you a much better idea of what the career is like, it tells you how to combine the subjects because the jobs need you to do that. Engineer is one, it needs physics, it needs maths – it's those sort of jobs that need them all. (Year 8 pupil, case study 3).

Pupils have particularly benefited from **understanding the importance of mathematics in relation to the other STEM subjects**:

> *We are doing STEM this week, which is D&T, maths and science…We designed a plane in science and had a competition for how fast it went…In maths we did about rockets, space and planets. It's been a more interesting week…Teachers don't make links as much usually.* (Year 8 pupil, case study 4)

> *Teachers don't usually split up things into different subjects. They don't tell us when maths is being used. If we were asked when maths was being used, we wouldn't be able to say.* (Year 8 pupil, case study 1).

Teachers have commented that pupils tend to compartmentalise their learning, not making links between what they have learned in one STEM subject and in another. As a result of interdisciplinary STEM activities, pupils have begun to realise that they will benefit from transferring learning between the subjects:

> *A simple example is that pupils tend to claim in science that they can't do graphs when teachers know that they have already done graphs in maths. (*Teacher consultee)

> *Pupils are now seeing the connections between the three subjects in their lessons. They are more interested, motivated and encouraged and they have enjoyed the activities they have undertaken.* (Teacher consultee)

> *Pupils now have 'light bulb moments' when they realise things are linked.* (Teacher consultee)

> *I think they have a better understanding of some of the relations to the real world and the real jobs and that we just happen to call these subjects to organise a timetable and to split these skills up. But they're more understanding of the fact that if you want to go and be, like a computer games guy or whatever, designer or something like that, that the skills you need to do that might come from this subject and this subject and things like that…they're fascinated by it.* (Teacher consultee)

4.2.6 Increased understanding of the importance of STEM subjects

Through their involvement in enhancement and enrichment activities, **pupils gained an awareness of why they need to learn the STEM subjects and their importance for work and life in general**:

> *It's important to study [STEM subjects] as you come across them even if it's not your job.* (Year 8 pupil, case study 4)

> *Yes, it's easy to forget science relates to the real world, and that it's not just about sitting in a lab or doing an exercise sheet. This made us*

think about how it relates to the real world and showed us that it's not just about science in school. (Year 8 pupil, case study 7*)*

I know more about how manufacturers decide which colours to use in food, what people like and don't like. (Year 9 pupil, case study 7)

It makes you realise how many times you use science and maths in your day-to-day lives. (Year 8 pupil, case study 1)

I can incorporate what I have learned into the way I live even if not into a career. (Year 8 pupil, case study 1)

You need to know about health and stuff for life generally, healthy living, exercise and diet and the effects of smoking. (Year 8 pupil, case study 7)

Pupils have particularly gained an increased awareness of the importance of mathematics, which many have commented that they usually find 'dull' and 'boring' because of the way that it is taught:

Well, I know that the data presentation skills we used can be used in jobs in the outside world, like for presenting sales data. (Year 9 pupil, case study 7)

You realise the subjects are more important when you see how they work together. You see how you use maths with the other subjects and see that it's more important. You see the links between the subjects. (Year 8 pupil, case study 1)

4.2.7 Increased awareness of STEM careers

Primarily through the input of outside professionals, pupils have gained **an increased awareness of the need for, and importance of, studying STEM subjects for a range of careers, as well as gaining more understanding of some of the careers that they might consider**:

We learned that we need maths, D&T and science for different types of jobs. We have been told about jobs. (Year 8 pupil, case study 4)

The talk was useful. It gave an insight into work in government. We don't often get to hear about jobs. (Year 8 pupil, case study 1)

We learned about all the jobs you could do using science in the future. (Year 9 pupil, case study 6)

They are learning more about careers in STEM and it's encouraging them to think about their options. (Teacher consultee)

Students' awareness [of STEM careers] has risen enormously, all the way through the school. (Teacher consultee)

4.2.8 Increased interest in STEM study and careers

Being involved in fun and 'hands-on' activities has **increased some pupils' interest in studying STEM subjects in the future and in considering STEM careers**. Some of these pupils were already thinking about further STEM study and careers, and the activities have increased their enthusiasm and eagerness; others have acquired a new interest after seeing **where STEM can lead and the importance of the STEM subjects, particularly mathematics**:

> *It made me more want to do science. I already had an initial plan but it made me more eager to pursue it.* (Year 11 pupil, case study 6)

> *I'm now a bit more interested in studying [STEM subjects]. You see how important maths is. You know science is anyway.* (Year 8 pupil, case study 1)

> *We learned about load of jobs that people did and got more insight. They gave us lots of examples of jobs to do with science and some people realised that they wanted to do science and they had to do it for the career they wanted to do.* (Year 11 pupil, case study 6)

> *If people were aware that every job you do needs maths and often science it would make a difference. [Pupils] should know why they have to do it.* (Year 10 pupil, case study 7)

> *I'm more interested in science maybe because it's more physical. You get to know more people and it makes it easier by knowing them and doing it.* (Year 8 pupils, case study 3)

> *It has made [pupils] consider different career paths, which would not normally be covered until GCSE.* (Teacher consultee)

Undertaking these types of activities has also increased pupils' confidence that they can study, and succeed in, STEM subjects and that **STEM careers are for both boys and girls**. In some cases, schools have targeted STEM activities particularly at girls, and they have successfully increased girls' confidence in STEM study and their interest in future careers that they might previously have believed fell within the domain of boys:

> *One of our aims was to get girls more involved. We've done quite a few girl-specific activities. Girls are becoming more aware that these are subjects they can do, and they're not just boys' things. They do value the importance of all these subjects. This is through the raised profile of all the STEM subjects.* (Teacher consultee)

> *We've had a few [girls] asking about careers in woodwork and construction after the activity that involved building the house.* (Teacher consultee)

In one school, pupils' increased interest and engagement in STEM subjects has led to increases in the number of girls opting to take product design at GCSE:

> *There are other areas of impact – product design, for example. Two years ago there were 14 students: 13 boys and one girl. This current Year 10, there are five girls and 18 boys. Both the overall number and the proportion of girls grew. For next year, there will be 22 students and nine of them are girls. That is a direct impact from all the work that has been done giving publicity to science and engineering and technology, making girls recognise that there is a career opportunity for them.* (Teacher consultee)

4.2.9 Increased achievement and attainment

In general, at this early stage, teachers and senior leaders do not believe that they can confidently say that project activities have led to the increased achievement and attainment of pupils, not least because of the range of factors that influence pupils' progress in school:

> *Students' PISA [Programme for International Student Assessment] scores have gone up year-on-year for the past four years. It is hard to isolate the STEM work as being solely, or mainly responsible.* (Teacher consultee)

Having said this, **some teachers have tentatively suggested that pupils' increased interest in, and motivation to learn, the STEM subjects as a result of their involvement in enhancement and enrichment activities is beginning to lead to increased achievement and attainment**[6]:

> *It's been about enjoyment and links between the subjects rather than attainment. However, enthusiasm will lead to better attainment.* (Teacher consultee)

> *I think the school is aiming to improve attainment, achievement and enjoyment for the students. All those other aspects: thinking, literacy and numeracy – all these go up as soon as students are more engaged in their learning.* (Teacher consultee)

[6] Several studies have reported an association between levels of motivation and interest in subjects and attainment and participation, for example Kuyper et al. (2000), Simpkins et al. (2006).

> *We are breaking the 60% barrier in maths [i.e. 60% of pupils achieving grades A*–C at GCSE] and we never reached above 50% before. We are also expecting better science results…you see students up and interested and actively engaged.* (Teacher consultee)

In one school, pupils who would normally not achieve GCSE qualifications have been awarded BTEC level 1 qualifications and are now more motivated to continue to a GCSE. The teacher consulted in this school has commented that the practical and varied nature of STEM activities has been a motivational factor:

> *It's been a bit of a motivator [delivering STEM vocational qualifications]. What I found was that as soon as we got through [the first year], some kids, once they got their BTEC Level 1 in science, said they wanted to do a single GCSE…I started it early for them because that's a possibility for them then, it's a hook into science. I think it's a really positive thing for them.*
>
> *I anticipate that this term that there will be three kids who'll get [BTEC Mathematical Applications in Engineering] by the end of this autumn 2011/12 term. If I really push them I might get some kids to the Level 2 aspect of that as it's a continuation of all the work they've been doing already.*

Some pupils have commented that the activities that they have undertaken have helped them to understand science and mathematics better and that this has led to increases in their interest and effort in STEM subjects. One pupil commented that she worked harder working in a group and pupils benefited from sharing knowledge:

> *It makes you work harder because you're working in a group; for example, you know who knows what and you can take those ideas and you know who doesn't know what and you can, say, give them your ideas. That helps you out. (*Year 8 pupil, case study 3*)*

Other pupils have reported that learning about the subjects together has increased their confidence in their ability to understand and succeed in the subjects. In some cases, something that they have learned in one subject has helped pupils perform better in another subject:

> *Say you're working in science and you're going to have to measure things with graphs…you already know how to measure because you've already learned it in maths. (*Year 8 pupil, case study 3)

In other cases, pupils think that their skills and knowledge have improved as they repeat their use across their different STEM classes:

> *It just gives you more experience. It basically makes life easier, it really does. Because in maths you learn all different kinds of angles, measurements and stuff like that, and then in science it adds to it…For Bridges [a STEM project], we had to put weights on the planks of wood of the bridges and we had to use the measurements and what we learned in maths to see how far the bridge would go down.* (Year 8 pupil, case study 3)

> *One subject relies on another. Like science, you need to use maths in certain situations and actually bringing it together you can find it easier to do the tasks.* (Year 9 pupil, case study 3)

4.3 Outcomes for teachers

A range of important outcomes for teachers have emerged as a result of their involvement in the STEM Initiative.

4.3.1 Improved relationships between staff working across STEM departments

The Wellcome Trust funding has provided the impetus for **the development of closer working relationships between staff working across the STEM departments**. These relationships are becoming stronger generally and, most noticeably, very strong working relationships are being developed in schools with a designated STEM team:

> *There has been much closer working between middle-level staff in the STEM departments. There has been a development of stronger partnerships with teachers working more closely together.* (Teacher consultee)

> *I have got to know people in different departments. I now have these relationships and connections.* (Teacher consultee)

> *This programme has given me the opportunity to work with colleagues who I'd never have had the opportunity to work with normally, which is nice.* (Teacher consultee)

> *There's been a lot of cooperation when I suppose there wouldn't have been before, and some of the comments I have had from the maths teachers have been really positive in that they were working with other people, they were doing things they wouldn't have been doing without this STEM Initiative…it's just a bit more 'team teaching', I suppose.* (Teacher consultee)

As mentioned previously, however, some schools have faced a loss of key STEM staff, which has led to the need for new relationships with staff in other departments to be forged.

4.3.2 Increased awareness of the curriculum in other STEM subjects and of potential links

The dedicated STEM teams also gained **an increased awareness of which concepts and topics closely link across the different STEM curricula**. This increased awareness of the STEM leads of the content of the curriculum in other STEM subjects is also 'filtering down' to other staff within the STEM departments. For example, there was a general awareness previously among science and technology teachers of what was taught in mathematics but little understanding of how and when topics were taught. This has now changed. The awareness of mathematics and science teachers of what is taught in D&T, and what equipment is available, has also increased.

Teachers have also begun to share good practice and learn from the expertise of teachers of other subjects:

> *Maths and science [teachers] have commented that they didn't realise the type of work that happened in the technology department. They didn't know what equipment and machinery we had.* (Teacher consultee)

> *I think it's been very beneficial…as a STEM subject teacher, I think I'm better because I understand really the other curriculum subjects that are so relevant to me but which previously I just knew very little about, to be honest. It's been an opportunity to work with people from other departments and set up projects and evaluate them.* (Teacher consultee)

> *We know what the other departments are doing, and what is going on. Science and technology are now part of the same faculty and are meeting regularly. STEM is a standard agenda item. We share good practice.* (Teacher consultee)

Within those schools that are revising schemes of work, there has been a realisation that teachers do not need to reinvent the wheel and that they can capitalise on learning that takes place in other STEM subjects.

However, in the five schools that focused on enhancement and enrichment, awareness of the curriculum in other subjects has not yet increased significantly:

> *We are a little bit more aware of the curriculum content of other subjects but we've not gained hugely in this way.* (Teacher consultee)

Teachers of STEM subjects who are not directly involved in the project, and teaching staff more generally, are more aware of what STEM is and the importance of interdisciplinary STEM activities.

4.3.3 Increased teacher confidence in cross-departmental working and undertaking interdisciplinary projects

The work to date has **increased the confidence of teachers in working with staff in other departments** and in delivering interdisciplinary enrichment activities and revising schemes of work. This will, it is hoped, lead to ongoing collaboration between the STEM departments:

> *We didn't have a great deal of confidence before in delivering interdisciplinary projects, but the funding has allowed us to get some training, buy resources and have the time to work together and plan the curriculum.* (Teacher consultee)

> *There will now be more cross-departmental working and projects. There is more confidence. Staff have seen how it worked and have more confidence.* (Teacher consultee)

Staff are also **more confident in trying out new things in the future:**

> *Teachers in science and maths have learned how to work together and appreciate what the other subject is doing. They have taught in a cross-curricular way during STEM week.* (Teacher consultee)

> *It has made me feel more creative and more confident in taking something on and trying things.* (Teacher consultee)

This was **most evident for mathematics teachers:**

> *For the teachers in the maths department, they've been provided with confidence to use more practical things within lessons. Next year, we're planning to continue this.* (Teacher consultee)

Staff also commented that making the links between the subjects more explicit in schemes of work is beginning to increase teachers' confidence in making those links in their teaching.

4.3.4 New learning and skills development

The teachers who have been consulted believe they have learned a great deal as a result of their involvement in the project, both in terms of their substantive knowledge of other STEM subjects and their teaching approaches/pedagogy. They have been given the opportunity to develop innovative enrichment projects that combine the three subjects within a real-life scenario and involve pupils in learning in a range of different ways, such as problem solving in teams, researching, and designing and making. **Teachers have also developed specific new skills (e.g. in delivering practical sessions)** in some cases, learning from staff in other departments. Teachers from across the STEM subjects have also been able to undertake some **very beneficial professional development**:

> *Teachers have learned a lot about how to build things and they have become more aware of how the subjects are closely linked…I've learned so much since I got involved in the Wellcome Trust work. I had no involvement in STEM previously.* (Teacher consultee)

> *We've got the technology department involved, and we've never previously been able to get this team involved. They've been key to this in the last few days and we've learned a lot from them.* (Teacher consultee)

> *I think, yes, I think maths would definitely want to go and do [the project] again. And I think we all learned a lot from doing it the first*

time because it was a very applied lesson and it's something we don't do very often [in mathematics]. (Teacher consultee)

I know there's a bank of teachers that I can turn to that can give me a much more substantial group of lessons than I would have had just as a D&T teacher, from the maths department but equally from the science department. (Teacher consultee)

It is believed that **this new learning has, and will, lead to improved teaching**, with teachers using a range of techniques:

It's about having a wider range of things in the toolbox to work from…giving the opportunity to share teaching practice and what excellence looks like in maths and science. (Teacher consultee)

In terms of recommending it to other people, I'd say every school should try it at least once a year because I think it's made a difference for my teaching practice if nothing else. (Teacher consultee)

By the very nature of introducing the changed schemes of work, teachers' pedagogy is being impacted. Teachers are presenting things in a more concrete, less abstract way. (Teacher consultee)

Teachers who have engaged professionals from outside to deliver activities have also been provided with new ideas to bring into their teaching and have a raised awareness of career opportunities and the application of STEM subjects within the workplace. This has been a particular outcome where teachers have been working with STEM Ambassadors or other representatives from industry, the public sector and universities:

Cross-curricular activities can help improve teaching as they help teachers contextualise their learning, make them more aware of the links between the other subjects and they learn about the application of the subjects from the outside STEM people coming in and talking to the pupils. (Teacher consultee)

You can do so much internally but staff need to be linked to outside opportunities as well – especially CPD around the world of work. (Teacher consultee)

The Camden STEM initiative has increased the attractiveness of some teachers in terms of promotion and progression:

There is a broad potential impact of the work and this doesn't just include the students. It is providing some very useful CPD for me and [my colleague]. We are gaining experience of delivering the curriculum in a more practical way, which provides us with advantageous experience. (Teacher consultee)

4.3.5 Higher expectations of pupils

In some cases, teachers now have higher expectations for pupils because they have evidence that pupils can rise to the challenge of working in different ways and achieve more, particularly when working on topics they find difficult:

Teachers have higher expectations of what pupils can achieve…they are finding ways of teaching areas that pupils find difficult more effectively…They try to teach it so that more [pupils] get it more quickly. (Teacher consultee)

4.3.6 Increased enjoyment and enthusiasm

In many cases, **being given the opportunity to be more innovative and creative with the curriculum has increased teachers' enthusiasm for, and enjoyment of, their work**. This will feed into their future teaching and is expected to have a knock-on positive impact on their pupils:

I feel invigorated and it's made me more enthusiastic about all areas of my work. It makes you think more diversely. It's been an opportunity to re-engage and re-enthuse…It's really important for teachers to do this so that they and students both enjoy the lessons…It's exciting as I have been in teaching a long time and a new opportunity has now opened up. (Teacher consultee)

I have enjoyed the days working with pupils off-timetable. It's been more memorable. (Teacher consultee)

It's been lovely taking students on interesting activities and seeing them become engaged. (Teacher consultee)

Staff have enjoyed working together and making the links between the subjects…teachers are more enthusiastic as they enjoyed doing something different, and maths teachers liked doing more practical things and working with people who know how to do this. (Teacher consultee)

Giving them professional autonomy and flexibility to adapt lessons for students re-energises people. (Senior leader consultee)

However, where schools have faced staffing issues and a reduction in senior leadership commitment to the project, this has sometimes resulted in a decrease in staff enthusiasm for the project.

4.4 Outcomes for schools

Much progress was made within participating schools in the first year of the project, detailed below. However, in the second year of the project, several schools faced challenges in maintaining momentum and sustaining outcomes, explored further in the following section.

4.4.1 Feeling more informed about options for interdisciplinary STEM activity and STEM initiatives

As part of the STEM Initiative**, the Wellcome Trust began supporting termly meetings for teachers of STEM, coordinated by the secondary science consultant in Camden. Schools have benefited significantly from these meetings**. An important impact has been teachers and schools feeling that they are more in the STEM 'loop' and accessing, and being provided with, more information and presentations on STEM initiatives and programmes (common opportunities accessed by the schools are summarised in a glossary at the end of this report). As a consequence, some schools have become involved in activities that they would not otherwise have been aware of. In addition, the meetings have encouraged staff to network, share progress and ideas, and learn about what other schools are doing. This has led to schools trying out new activities and to further collaboration:

> *Now, because of the Wellcome Trust work, the school is more in the STEM 'loop'.* (Teacher consultee)

> *The meetings with other schools that were facilitated by Wellcome Trust were really good.* (Teacher consultee)

Also, very importantly, the meetings have helped staff to maintain their enthusiasm and motivation for driving STEM forward within their school even when they are facing challenges. Several teachers have commented that

undertaking their project alone without the chance to network with other teachers in their local authority would have been a much harder task.

There is still much enthusiasm for further opportunities to share learning and best practice in relation to the work of Camden schools on STEM.

4.4.2 Increased awareness of, and commitment to, interdisciplinary STEM activity

Another key outcome for schools in the first year of the project was **an increasing awareness of interdisciplinary STEM activity** and the impetus for schools to start work in relation to it:

> *The school's work around STEM has really started as a result of the Wellcome Trust funding...Certainly STEM work has become more pivotal to the school, and the work will really be about embedding it.* (Teacher consultee)

> *Other teachers are linking in even if they have not been involved. They are realising what STEM is (and weren't aware of it before) and that more will happen in a cross-curricular way in the school in the future. People are recognising the importance of STEM.* (Teacher consultee)

> *Everyone's aware of the STEM agenda now, which was not at all on the radar before...It just wasn't part of the conversation at all. It is now part of the School Development Plan...the change has gone deep. It wouldn't have happened at all [without the Wellcome Trust programme]. I hadn't even heard of it before, before I went on the training day.* (Teacher consultee)

Managers and leaders 'further up the food chain' are becoming more aware that these links exist and should be maximised.

Particularly in the first year of the project, an increased commitment to making STEM a priority was also evident among senior leaders, who saw the benefits of linking the subjects via enhancement and enrichment activities and/or within the regular curriculum. In one school, this increased commitment manifested itself in the inclusion of STEM in whole school staff meetings and STEM being included on the regular agenda of departmental meetings. In another school, a decision was made for the STEM Coordinator to be line

managed by a senior leader, which provided evidence of senior leaders' commitment to STEM. In other schools, senior leaders began to be more convinced of the benefits of interdisciplinary STEM; however, their involvement in the work was sometimes limited as they delegated responsibility for the delivery of activities to the STEM leads.

4.4.3 Closer links between the STEM departments

In some cases, the STEM Initiative has formalised cross-departmental working and provided a structure and purpose to the collaboration, enabling staff to be more ambitious in their plans:

> *Teachers have always had good intentions to work together and have done so, but the funding has given the collaboration a complete structure…teachers have been able to be more ambitious, and it has made collaboration more purposeful.* (Teacher consultee)

In some cases, **closer links between the STEM departments have resulted in improvements in teaching**. A consultee in one school has commented that closer working between the STEM departments is beginning to result in an improved Key Stage 3 curriculum. Another consultee has reported that a major success of the work has been the development and embedding of links across the Key Stage 3 curriculum. This includes teachers using the same terminology across the STEM subjects, which has improved teaching and the pupil learning experience.

4.4.4 Staff development and retention

As a result of the new challenge and professional development that has been offered to them, some staff have commented that they are more likely to remain within their current schools. In other cases**, teachers have gained very beneficial development that will help them progress within the profession** even if they do not stay at their current school:

> *It's work like this that makes a difference in terms of retaining staff, allowing people across different faculties at different levels to work collaboratively, run whole school activities and be successful. It can lead to promotion.* (Teacher consultee)

4.5 Sustainability of outcomes

As mentioned above, **where one-off enhancement and enrichment activities have been delivered to pupils, it is likely that the initial outcomes for pupils will diminish as memory of the activity and its impetus fade, especially if pupils return to normal lessons in which teaching approaches have not changed**:

> *It's not impacted on my enjoyment of lessons. What we did was not like what we do in technology lessons so you can't compare it. We would have to carry on learning in that way to carry on the impacts. (*Year 8 pupil, case study 1)

> *It's interesting at the time and then you don't do anything further about it so there's not much point. It's a one-off, and then we are back to normal lessons. We should do this kind of thing [trips out of school, enrichment activities] more often. (*Year 9 pupil, case study 6)

It is, therefore, important that in these schools pupils experience ongoing opportunities to engage in interdisciplinary activities (e.g. at least once a term):

> *Give everyone a chance to do it, give everyone a fair opportunity and do more of it [trips, enrichment activities]…It helps you learn and understand more.* (Year 9 pupil, case study 6)

The **importance of targeting activities at Year 9 pupils before they make their GCSE choices has also been emphasised**:

> *There should be more projects like this for all years and throughout the year…It would be particularly good to do something like this before you choose your GCSEs. You will then be more interested in science for your GCSEs. (*Year 8 pupil, case study 1)

> *They should keep reminding [pupils choosing GCSE subjects] that we need the [STEM] subjects for jobs, and we should talk to more people doing jobs.* (Year 10 pupil, case study 7)

> *We should carry on doing it every year and link back to what we have done before. It would be a boost to do it before choosing GCSEs.* (Year 8 pupil, case study 7)
>
> *We took Year 9 pupils to the Big Bang Fair as it was close to choosing their options.* (Teacher consultee)

As two pupils pointed out, preparatory work helps them to gain maximum benefit from enhancement and enrichment activities, as well as follow up and review of what has been learned in regular lessons:

> *You should do more background before you go and do work on it afterwards. Otherwise you do it and then forget about it. (*Year 9 pupil, case study 6)
>
> *It would have been good if we had been able to analyse the results afterwards. (*Year 13 pupil, case study 7*)*

4.6 Additionality

The HM Treasury 'Green Book'[7] defines the concept of additionality as an impact arising from an intervention that would not have occurred in the absence of the intervention.

All of the schools that have received funding from the Wellcome Trust have commented that **the activities that they have delivered would either not have occurred at all or would have been much less likely to have been delivered without the Wellcome Trust funding**. In addition, if they had taken place at all, they would have been on a much smaller scale or would not have included the same level of resources or the involvement of external speakers and presenters. As five consultees commented:

> *The work would have been much less likely to have happened without the funding, though you don't need a huge amount of funding. Help with buying resources is useful, paying for cover and CPD.* (Teacher consultee)
>
> *We have developed an exciting programme that is really invigorating our teaching. We would have never been able to fund the*

[7] HM Treasury. The Green Book: Appraisal and Evaluation in Central Government; 2003.

> *development work for the new programme, buy the necessary equipment and resources and undertake the professional development that has gone alongside it without the Wellcome Trust funds.* (Teacher consultee)
>
> *It would have been impossible to have achieved what we have without the Wellcome Trust funding.* (Teacher consultee)
>
> *The impression I have is that schools have been given the freedom to do something they feel is very valuable. They feel that they are included in something bigger than their school…It has opened doors that were closed before.* (Teacher consultee)
>
> *The funding has allowed us to undertake the activities at a more involved level; for example, purchasing the cameras for the STEM day and getting external presenters for various sessions.* (Teacher consultee)

It should also be noted, however, that there is a wide variety of external resources and schemes, used by several schools as part of the Camden STEM Initiative, that are free and can be accessed by any school, as detailed in the glossary (see Appendix 2). These free resources and schemes can provide invaluable support and opportunities to schools in their delivery of interdisciplinary STEM activities, particularly enrichment and enhancement activities.

5 What is working well?

The focus of this section is on learning what works well in setting up and delivering interdisciplinary STEM projects and the range of factors that are required for projects to be successful. Some examples of activities that have worked well are also provided.

Of key importance to the success of STEM interdisciplinary activities are senior leadership commitment and support and having a designated STEM Coordinator/lead in each department who is provided with regular planning time. It is also important to allocate staff to the work who are passionate about interdisciplinary STEM activity. Progress can be achieved solely with enthusiastic staff, but sustainability of momentum is likely to become an issue without senior leadership support.

5.1 Overview of key requirements for successful interdisciplinary STEM activity

Schools identified several key factors for successful STEM work, which are outlined in Figure 5.1 and explored in more detail in the following sections.

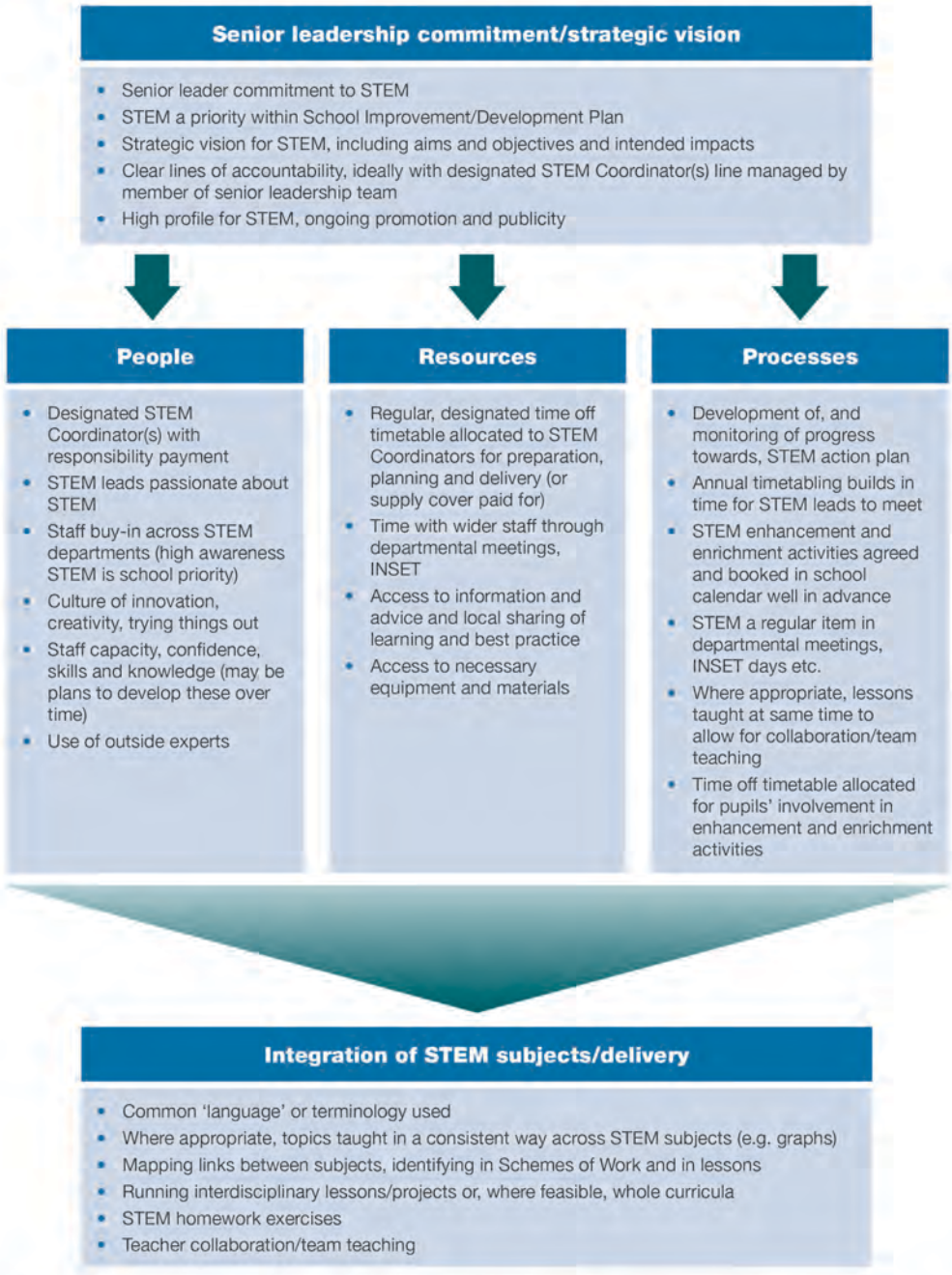

Fig. 5.1 Overview of the key factors for success for interdisciplinary STEM activity

5.2 Senior leadership commitment/strategic vision

Of key importance to the successful delivery, embedding and sustainability of interdisciplinary STEM projects is strong senior leadership and head of department commitment. Ideally, this would mean that STEM was evident as a high priority within the School Development Plan or School Improvement Plan, that designated STEM staff were in place who received responsibility payments (see Section 5.3 on people), and that regular time on-timetable was allocated for planning meetings (see Section 5.4 on resources). Senior leaders need to be convinced of the value and benefits of interdisciplinary STEM activity (e.g. motivating and engaging pupils, the development of transferable skills and conceptual thinking, and broadening career horizons and encouraging further STEM study, etc.) and that a focus on STEM may support a priority to raise attainment.

Where senior leadership commitment is less strong, or not in existence at all, some progress can be made by enthusiastic and inspired staff, but the pace of change can be slow and sustainability is likely to become an issue:

> *If teachers and [the senior management team] are aligned in their understanding and support for cross-subject links, there is a greater chance that they will be sustainable.* (Teacher consultee)

> *[Senior leadership] support is vital: without it, you're not going anywhere.* (Teacher consultee)

> *If the schools can be convinced at a senior level, this is important. There needs to be more than just keen people running about at departmental level trying to do things.* (Teacher consultee)

> *The senior leadership has been very supportive. The STEM stuff has been in the SDP [School Development Plan], which is the most important document for the school. STEM is right there, it's in our SDP, so we've got support for it, all the way from the top of the school.* (Teacher consultee)

> *Get SMT on board and make STEM a priority. Give staff responsibility and time. Teachers need to feel that the time and effort that they put in is appreciated. You need a team of people working together. Teachers need time to work across departments.* (Teacher consultee)

> *My advice to other schools would be to take a risk and go for it. There are more opportunities than there are barriers and, as long as the leadership team is behind it, there is no reason not to go for it.* (Teacher consultee)

Senior leadership commitment helps to develop and maintain a high profile for STEM through ongoing promotion and publicity. **It is important to use every opportunity to promote STEM and what has been achieved**. This includes having STEM noticeboards that are regularly updated throughout the school and having STEM as a regular item on subject curriculum meetings:

> *On the most basic level, displays, I think you need to be looking at having displays around school that promote STEM. If nothing else happens, I will make sure there is a STEM noticeboard that carries the STEM message because I think even if kids just walk past they do absorb the information over time.* (Teacher consultee)

The importance of the 'visibility of successes' in relation to STEM activities was also highlighted:

> *Visibility of successes is also important [to support impacts] such as pupils being engaged, being motivated and [communicating to teachers] that it's making their lives easier as a teacher because students are more motivated and responding better.* (Senior leader consultee)

5.3 People

Where schools have appointed a designated STEM Coordinator or Coordinators, this has made an immediate positive impact in terms of raising the profile of STEM work in these schools. In others, the reputation of those delivering the programme as being successful teachers and (current or past) heads of department has enabled the work to be viewed as high profile. **Giving the STEM leads a formal responsibility and job description has helped to give** these staff status and recognition within the school and made it clear to all what their role entails:

> *Unless you put [the STEM Coordinator role] into someone's job description, it doesn't happen because there's just not enough hours in the day…I think what's been successful about the project is because we've had job descriptions, we have had a clear path, we had an action plan and had to put steps in…I think that's what's made the project successful…so I think actually having three people in a role who were therefore obliged to meet, to put things in place, was key. It needs someone to say 'I am responsible for this, I need to do this to make sure everyone else does'.* (Teacher consultee)

I has also been important to pay staff a responsibility payment for their additional STEM responsibilities.

Teachers and senior leaders have stressed the need for **the workload to be shared by having a STEM lead from each department who is involved in planning and delivery** and to engage other staff from across the STEM departments. This is key to successful delivery and the longer-term sustainability of the work:

> *With a full timetable it's difficult – you need a team of people. It's important to make sure that others are capable of running events for sustainability reasons. This would ensure that the work remains a priority...My advice to other schools would be to make sure that you have all departments involved. You need as many staff willing to participate as possible.* (Teacher consultee)

> *You really need a dedicated person or people to plan and deliver STEM activities. There could be an argument for each department to be allocated some time, for example one hour a week as a real minimum…It's important to share responsibility and to get everyone involved.* (Teacher consultee)

> *You need shared ownership and involvement.* (Teacher consultee)

Departmental representatives need to be 'fired up' and passionate about STEM and to use their enthusiasm to bring their whole department on board:

> *You just need staff enthusiasm for it to work.* (Teacher consultee)

> *You need teachers who have a genuine interest in STEM and a genuine interest in moving forward.* (Teacher consultee)

> *You need 'Ambassadors' within the discipline because if they're not present it seems like a management pressure. You need to have subject leaders to motivate staff…You have the Ambassadors to facilitate it, drive it and start it up, but it's important to have three or four people to pass the information on. Otherwise, it's just an era [i.e. it may not be sustained].* (Teacher consultee)

Staff who are leading and delivering activities also need to be encouraged and inspired and to **feel that their work is appreciated and valued:**

> *It is essential that the staff who are implementing any STEM programme are encouraged – they need to be shown that their efforts are appreciated.* (Teacher consultee)

> *You need people from your team to feel valued and like they're an important part of the initiative. So you need to be able to inspire them.* (Teacher consultee)

In making links between the STEM subjects, it is the attitude of staff that makes the difference**. In schools where there was already an openness and enthusiasm for doing things differently and an appetite for innovation** (and where staff were already willing to step out of their 'comfort zone'), **it was easier to deliver the project:**

> *It hasn't been difficult to implement as teachers are used to sharing information and the school has very enthusiastic and committed teachers…Teachers within all three of the teams are accommodating with new approaches…The school has always been keen to engage with pedagogical change and 'thinking outside of the box' is welcomed.* (Teacher consultee)

> *We have very forward-thinking staff, we have interactive staff, everyone always wants to do something different here…because we all want the best for the kids, and we can see they'll benefit from [cross-curricular activities], and how it will benefit our teaching as well… because we enjoy what we do and where we work, our joint working is positive.* (Teacher consultee)

> *There's quite a culture [of cross-curricular working] in the school. Sometimes it's a bit frustrating because you've got an exam coming up, but on the other hand, there are lots of trips and activities; you don't just expect people in a classroom every day.* (Teacher consultee)

It has been commented that **it may be more effective to choose teachers who are confident** in delivering interdisciplinary or enrichment activities **to run the activity several times or to provide support to those who are less confident**.

Owing to the many demands on teachers, **it is helpful and motivating if teachers gain some benefit themselves** from the work in terms of professional development or new inspiration, and this aspect of the work should be highlighted and made explicit:

> *There are always many things going on within school and there is a danger that the STEM initiatives may be seen as 'just another thing' that is going on. To overcome this, there needs to be a sense that the initiative provides a refreshing aspect for teachers, something that feeds them professionally.* (Teacher consultee)

In the setting up and delivery of projects, having some **administrative support** is also useful:

> *It is easy to underestimate how much admin time goes into the organisation of events such as the STEM days. We were able to enlist the help of a science technician and ICT technician from within the school – they were able to help out with getting some of the activities set up.* (Teacher consultee)

Bringing in professionals from outside to lead or support activities and deliver talks and lectures is also very beneficial. This can provide pupils with positive role models and greater insight into potential STEM careers and how to get into them, as well as enthusing pupils about STEM more generally:

> *To have real scientists coming into school to talk about their work, to talk about what they did at school and why [STEM is] important, that is invaluable.* (Teacher consultee)

It can also be beneficial to involve older pupils in the delivery of activities because this helps them to develop transferable skills (e.g. leadership skills), which could be used to gain further qualifications such as a CREST Award.

5.4 Resources

Having designated planning time built into the timetable, during which teachers across departments can meet and plan curriculum change and enhancement and enrichment activities, has been very beneficial for schools involved in the project. This is particularly important when major changes to schemes of work are being made. In two schools, which have very successfully revised schemes of work to make links between the STEM subjects, designated planning time for this work was written into the timetable. In one of these, the curriculum for Years 10 and 11 has been totally rewritten to integrate science, D&T and mathematics, and staff are therefore able to use the regular planning time that is allocated to the delivery of the Key Stage 4 curriculum. In the other school, three staff have been allocated one hour every two weeks to meet and plan, enabling them to move forwards quickly with their plans for transforming the curriculum:

> *Structural support is required to timetable time to meet and allow time for things to happen.* (Teacher consultee)

> *The time really needs to be built into the timetable; for example, a STEM planning hour every week.* (Teacher consultee)

> *The only thing that teachers always want is time. You can do so much with time. We have an hour's meeting, but we'll come out of it and do various tasks. You actually get a lot more than an hour's work out of it.* (Teacher consultee)

> *We wouldn't have been given meeting time if they weren't supportive, if there is no meeting time there's no time to plan. So…it wouldn't happen.* (Teacher consultee)

In another school, staff used INSET time for planning. Other schools used Wellcome Trust funding to pay for supply cover to allow teachers time off-timetable for meetings. However, this may only allow for occasional or ad-hoc meetings and can result in slow progress and a loss of momentum. If designated time is not feasible, then **it is important for teachers of STEM subjects to find a regular time slot** when they are all free to meet together, preferably during the school day:

> *My advice would be to make sure you get time together to plan and not just as an after-school thing.* (Teacher consultee)

Several teachers commented that planning enhancement and enrichment activities and developing schemes of work has taken much more time than they expected and that it is essential to leave plenty of time for planning and to start early:

> *You need to start planning early. Planning is the most important thing to ensure that the work runs smoothly.* (Teacher consultee)

5.5 Processes

STEM leads can be more effective if they **develop an action plan** from the start and monitor progress towards it. Consultees from one school suggested that a three-year plan would be ideal, particularly when the focus is on revising schemes of work. A senior leader from another school commented on the need for **a clear, structured action plan with milestones and**

timescales against which progress can be reviewed and the need for teachers to possess project management skills:

> *You need to have a clear timetable and milestones that you are working towards so that you can review and see if you have achieved what you set out to do. You need to review whether you are on track and, if not, why not, and rethink if needed…People need to know what they are doing and why. This includes teachers, support staff and pupils…You can be very creative and yet structured.* (Senior leader consultee)

The action plan should outline roles and responsibilities, aims, objectives, activities and timescales, and outcomes – particularly outcomes for pupils – and detail how progress in planning and delivering activities, and in achieving outcomes, will be measured and tracked.

All of the staff involved in the work need to be clear about what they are doing and understand the benefits, and **it's important to regularly provide teachers with as much information as possible,** to make the delivery of lessons and activities as straightforward as they can be. This includes being clear about the aims of activities, what they will entail and when they will be delivered, and it also includes sharing learning and resources. This is particularly important for teachers who are less confident or less experienced in interdisciplinary working. The regular communication of plans, and communication in a variety of forms, is very important:

> *You need good communication in lots of different forms enabling staff to see that it's their responsibility; share information and curriculum links, which all helps to generate energy and embed links and share ideas of how to do things.* (Teacher consultee)

5.6 Integration of STEM subjects/delivery

In terms of the content and delivery of enhancement and enrichment activities, **practical activities are particularly motivating and engaging for pupils** and the STEM Initiative has provided significant evidence in this respect. In addition, **contextualising learning is also very successful** and is a common mode of delivery in science and technology lessons but tends to be more rarely used in mathematics. However, through their Wellcome Trust

work, **several schools have found mathematics activities undertaken within a real life context to work particularly effectively**. Schools have drawn case study problems from Bowland Mathematics (**www.bowlandmathematics.org.uk**), and seeing the application of what they are learning has engaged pupils with mathematics and helped them see its relevance.

Pupils have also benefited from working in groups with pupils other than their close friends and learning in different ways (e.g. problem solving, undertaking research and debating). In addition, **ensuring that teachers are teaching to their strengths and, therefore, confident works well.** As one consultee pointed out: 'Make sure that you enjoy the topics that you pick as you will then be enthusiastic delivering them to pupils.'

All schools have used a proportion of the Wellcome Trust funding to buy resources and materials, or to pay for speakers, to support their enhancement and enrichment work, and they noted **it is important to be properly resourced** when undertaking activities of this type. Without the Wellcome Trust funding, it would not have been possible for schools to have delivered some activities in their entirety. Other activities would have been less well resourced or improperly resourced, or there would have been restrictions on the number of pupils taking part. The types of resources that schools have bought with the funding include data loggers, microscopes and stethoscopes and kits to build models, for example, through the Science Enhancement Programme.

Several schools have delivered STEM enhancement and enrichment activities during regular lessons rather than taking pupils off-timetable for the day. However, teachers have commented that delivering enhancement and enrichment activities in this way can result in several logistical issues and that, **if possible, it is better to take pupils off-timetable for the day or morning for enhancement and enrichment activities.**

Several schools delivered their enhancement and enrichment activities and undertook their planning around schemes of work, at the end of the summer term after the exam pressure had subsided. Consultees suggested that the end of summer term is a good time for planning because teachers are less

pressured and are, therefore, more open to considering different teaching approaches. As one consultee commented: 'Teachers are not just focused on teaching to get pupils through exams. They can widen the topics that they study a bit and, crucially, use different teaching methods (e.g. problem solving) that take longer for pupils but turn out to be better learning experiences'. In other schools, however, it was thought that the pressure on teachers was the same all year round.

Most of the schools targeted their activities at Key Stage 3 because there is more flexibility in the curriculum and assessment at this stage than at Key Stages 4 and 5. **Providing pupils in Year 9 with a STEM 'boost' before they choose their GCSEs can be effective** in terms of influencing their choices. However, some teachers commented that **it is beneficial to involve every year group in enhancement and enrichment activities to maintain their ongoing engagement in STEM subjects**. Some schools effectively targeted under-achievers, gifted and talented pupils, and girls. In one school, an engineering activity run for Year 8 girls was effective in changing perceptions and stereotypes and raising aspirations.

In terms of piloting activities for the first time, consultees have stressed that it is important to **ask pupils their opinions on the content, delivery and outcomes of activities and how they might be improved and to make adjustments based on what does and does not work:**

> *It's important to learn from what works and doesn't work. For example, we had four speakers at [one STEM day] and it was too much, so we've changed that now.* (Teacher consultee)

Other ways of judging the success of activities are teacher observation of pupil motivation and engagement in tasks and pupil interest in, and uptake of, future enhancement and enrichment activities (e.g. participation in STEM Clubs). Pupils' progress and attainment can also be tracked but, as mentioned in Section 4.2.9, it would be difficult to ascertain the extent to which certain activities have impacted on attainment owing to the range of other influences on pupils' progress.

Two consultees stressed the importance of not being overambitious and how it was best to **start out small and develop your work from there**:

It's a good idea to start small and manageable and to grow the programme gradually. It would be a shame to start strong and have the programme steadily atrophy from there. (Teacher consultee)

It's better to do one or two things and do them well – start small and make it achievable. (Teacher consultee)

5.7 Examples of successful activities

There are several examples of STEM activities that teachers reported were particularly successful. Some of these examples are highlighted below.

- **Revisions to Key Stage 3 schemes of work**. Three schools focused their energies on revising their schemes of work within Key Stage 3. Two of these mapped the curriculum content in STEM subjects and, for each topic, they identified the links with other STEM subjects as well as logging when similar topics within each subject were taught. This enabled teachers to identify and discuss the links in their lessons. One of these schools also devised resources to support teachers in their delivery of particular topics and used a coloured logo for each STEM subject when it was mentioned. Where topics can be taught in the same way across the subjects, teachers were encouraged to use the same resources. Teachers also worked together across departments to ensure that they used consistent language and taught topics that fall into different subjects in a similar way (e.g. graphs and averages) to reinforce pupils' learning. If topics need to be taught slightly differently, teachers become aware of this and can highlight the differences to pupils. Changes made to schemes of work were piloted and tweaked before they were rolled out further. These activities were successful, and the changes made are now embedded in the curriculum and sustainable over the longer term. One school mentioned that documents were made available to staff through file sharing networks.

- **Revision to Key Stage 4.** One school, which has more flexibility at Key Stage 4, revised the curriculum to be entirely interdisciplinary: science, mathematics and D&T were taught together, using the theme of alternative energies. This school used a range of qualifications to accredit pupils'

work, such as BTEC Applied Science Introductory Course, BTEC in Mathematical Applications in Engineering and OCR qualifications. Progress and attainment of pupils has rose during this period.

- **STEM homework exercises.** One of the schools that revised schemes of work developed accompanying STEM homework exercises for Year 7 that combined learning from across science, mathematics and D&T lessons. An exercise was designed for each half term, so there were six in total. For each of the exercises, there was a stronger link to one particular subject, and the homework was given out and marked by teachers of this subject. The pupils' work was then passed on to other teachers of STEM subjects. The school achieved the highest returns of completed homework for these specific exercises:

  > *Some of the maths teachers have commented that the Year 7 homework was actually the highest returned homework that they've done. Homework is very poorly attended to at this school, and [the pupils] seemed to enjoy the fact that they'd already done [the particular maths homework activity], they'd already talked about everything in science and now they were doing something related to it – they felt a kind of continuity there, and 'Ah, yeah, we're doing this again,' and I think they got quite a lot back.* (Teacher consultee)

- **STEM enhancement and enrichment activities.** Schools delivered a wide range of enhancement and enrichment activities – both on- and off-timetable – focusing on a variety of topics, including the environment and sustainability, building and racing radio race cars, solar car challenge, natural disasters, patterns in nature, the Olympics, disease outbreak, health, rockets, building bridges, space and planets, food and smoothies, biodiversity, and Save our Seeds. In some cases, speakers and individuals running workshops (e.g. STEM Ambassadors, university staff, specialists in particular fields, Smallpeice Trust, Young Engineers) were invited in as part of the day and, in others, pupils were taken on visits (e.g. to the Science Museum, Natural History Museum, Millennium Seed Bank, IMeche, Big Bang Fair and London universities such as Imperial College or UCL). In a few cases, STEM lessons (e.g. rivers of the world, rockets and bridges) were developed from activities that are now to be embedded within the curriculum over the longer term. In addition, in one school, a

small group of Year 9 pupils worked on a solar car challenge that enabled them to achieve a bronze CREST Award, and this was especially motivating for pupils. Other schools developed activities around challenges such as the Rolls Royce Science Prize and Serious About Science Competition. Schools also very successfully set up and ran STEM Clubs, and there is some interest in more focus being placed on engineering in the future.

- **Use of outside space.** Two schools developed a school garden and used this outside space for a range of activities, such as data handling in mathematics (looking at populations and areas), growing plants and vegetables in different conditions (including building geodesic domes), and growing food to cook in food technology. These schools commented that there are many more opportunities to use the outside resource for experiments and data analysis across STEM.

- **Use of pre-prepared and other external resources.** Some schools effectively drew on a range of external resources, such as those available from the Science Museum and Young Engineers. One school filtered the vast range of resources available through the National STEM Centre e-library and drew on those which were appropriate. Schools commented that more sharing of resources across schools, when they have already been piloted and tweaked, would be beneficial.

- **Inclusion of STEM quiz in school diary.** One school included a STEM quiz page in the diary that pupils are given at the beginning of the school year. This made a great difference as the pupils completed the quiz and were interested in STEM from the start of the year ('*you know that made a massive difference because it meant that [the Year 7s] understood and had a curiosity about STEM from the first minute they walked into the school*').

- **Encouraging pupils to choose STEM options for GCSE.** One school focused on raising Year 9 pupils' awareness of the GCSE STEM options available to them using several strategies, including:

- letters to parents of pupils achieving highly in one or more STEM subject(s) to highlight the option of doing other STEM subjects too
- presentations on STEM careers at options evenings
- **STEM teachers sitting together at options events** so that they could jointly advise pupils and discuss the need to, and benefits of, combining different subjects:

  We made sure that [maths, science and D&T] input to the tables [at the options mornings] together so that when young people came we were all able to say 'If you want to do maths, then maybe you should think about doing product design and science as well.' The aim was to get them thinking more clearly about their option choices…We weren't able to affect the timetabling of options, but we were able to affect students' decision making. (Teacher consultee).

- **Team teaching.** In a few schools, teachers were starting to teach classes together, which enabled them to support, and learn from, each other; in one school, the ultimate aim was to raise the level of teaching to that of the highest performing department. This type of collaborative working has to be built into the timetable to be feasible.

Several consultees commented that **the Camden STEM meetings** – meetings organised by the Local Authority and the Wellcome Trust for teachers of STEM to come together to share ideas and project updates – **represent good practice** and that they have been invaluable.

6. What challenges and barriers are being faced?

Earlier in the evaluation, several challenges were identified by interviewees involved in the Camden STEM Initiative. At the end of year one, there was optimism that these challenges could be overcome and that activities supported through Wellcome Trust funding would leave a secure legacy. However, a key caveat was the support from senior leaders for STEM interdisciplinary working, something that was evident in only a small minority of schools at baseline (i.e. before they received funding). Further research – conducted in the summer of 2011 – confirms the pivotal nature of senior leadership support and shows how its absence can both create and compound a wide range of other challenges. This section explores the range of challenges and barriers that schools have faced in implementing their Wellcome Trust projects.

6.1 Overview of key challenges and barriers for interdisciplinary STEM activity

The diagram in section 5 provided an overview of the key requirements for successful interdisciplinary STEM activity. Here, we explore the reverse situation. Figure 6.1 shows the key features of the school context and environment that lead to challenges and barriers to interdisciplinary STEM activity.

Over the course of the STEM initiative, **the crucial importance of senior leadership team support for effective interdisciplinary working** has become clear. In addition to this key requirement, other areas in which challenges have emerged are people, resources and processes. Typically, these challenges have directly resulted from limited senior leadership commitment to STEM or their resolution has been hindered by this shortage of commitment. A relatively small number of challenges are specific to the task of integrating STEM subjects (the final box), and it is believed that these can be overcome.

Sections 6.2 to 6.6 provide a more detailed description of each area of challenge.

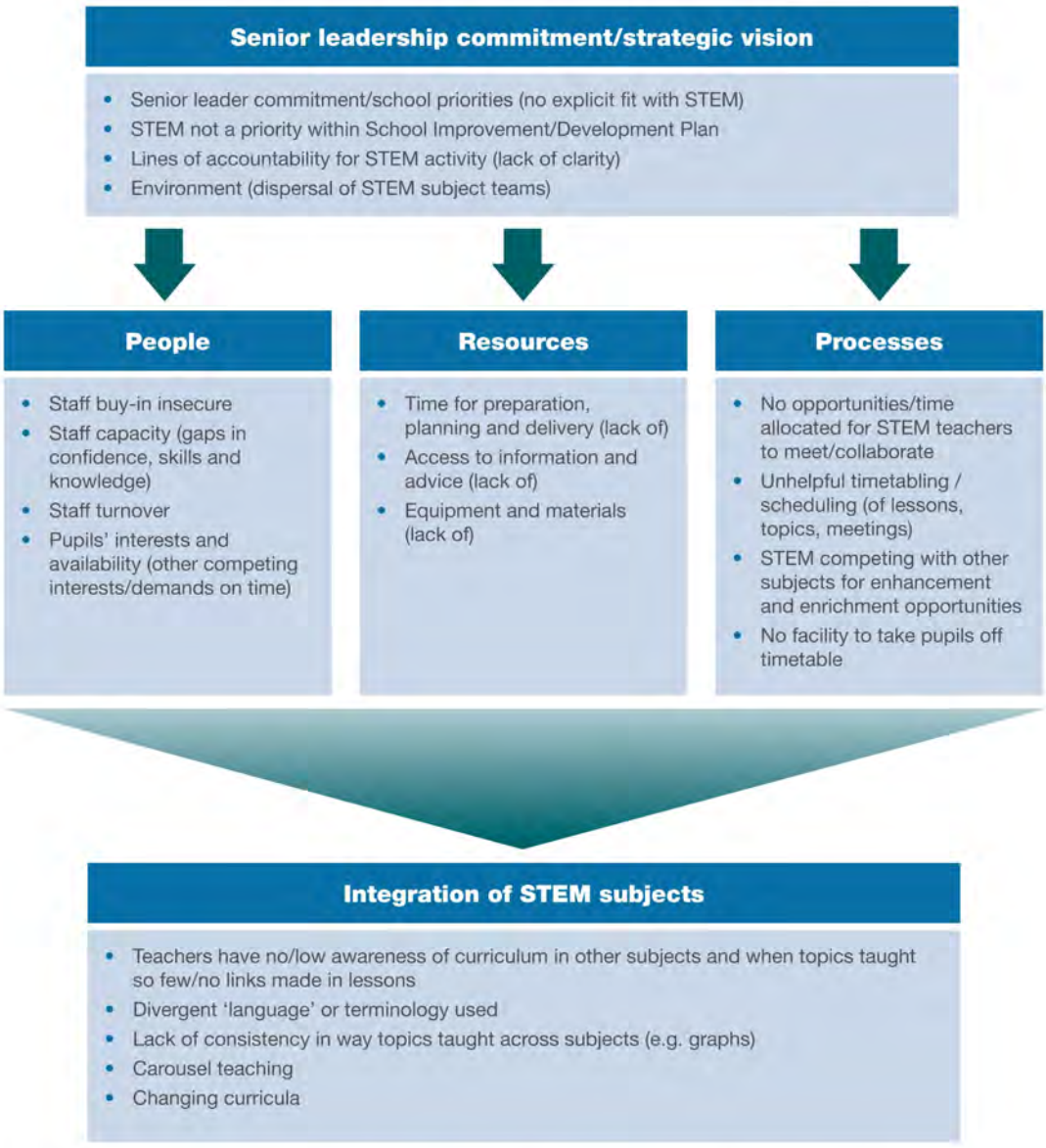

Fig. 6.1 Overview of the barriers and challenges for interdisciplinary STEM activity

6.2 Senior leadership commitment/strategic vision

In schools where interdisciplinary STEM activity has limited senior leadership support and is a generally low priority, change has been difficult to bring about and maintain. In some cases, senior leaders' interest and energy have been directed towards areas of school improvement perceived as more likely to have a short- to medium-term impact on

attainment, especially on Key Stage 4 results. It seems that **more evidence (or dissemination of evidence) is required to demonstrate to senior leaders that interdisciplinary STEM activity can in fact support school improvement and efforts to raise pupils' levels of engagement and attainment in STEM subjects.**

In one of the case study schools, a change in senior leadership led to interdisciplinary STEM activity taking a lower priority and the relevance of the proposed activities to the school's development and improvement priorities being questioned. **Unless STEM is formalised as a priority in a School Improvement or Development Plan, with STEM framed either as a priority in itself or as a mechanism for addressing other priorities, senior leadership support can decrease as a result of changes** in personnel, availability of incentives (e.g. a large grant) and other factors.

Various other challenges are associated with low senior leadership support, including the development of a **strategic vision** and clear **lines of accountability** for its delivery. The experiences of the participating schools suggest that without high-level involvement and drive (i.e. above departmental level), work is unlikely to be sufficiently strategic or high profile to bring about a major cultural shift. Moreover, the authority and accountability for initiating changes in structures (e.g. faculties, departments and teams) and historic ways of working will be – and in several of the schools clearly has been – lacking. Furthermore, people and resources – most critically non-contact time – have in such circumstances proved hard to mobilise and organise (see sections 6.3 and 6.4, below).

A lack of strategic vision can also result in the physical dispersal of the different STEM departments (although this can also be due to long-standing issues outside of the senior leader's control), and this has proved a hindrance for some of the schools. For example, the technology department is sometimes on the other side of the campus to science, which makes collaborative working difficult. It seems more common for science and mathematics departments to be located near to each other. Where departments are not co-located, staff have to make additional efforts to meet, and this can slow and limit progress:

> *Not enough links have been made between the subjects up to now. It's the hardest challenge as the site does not lend itself to collaborative working. We have to find a way to crack this...It's about the physical organisation of the school and about how you organise teams.* (Teacher consultee)

> *Because of the geography of the school building it's not feasible to rewrite a project taught across the three subjects. It would be a logistical nightmare.* (Teacher consultee)

Two of the schools were expecting to be rebuilt through the Building Schools for the Future programme, and plans included the creation of a STEM 'cluster'. They were disappointed to hear that this building work will not now go ahead.

6.3 People

Several challenges associated with people (mostly staff, but to some extent pupils) have been identified. **Contributors have emphasised the difficulties associated with, but the importance of securing, staff buy-in** at all levels *and* across all relevant departments. In several schools, there was a sense of two of the three key departments being on board, but for different (localised) reasons, securing sign-up from the third had proved difficult.

Another related concern, in some cases, is staff capacity, not in the sense of time (a significant issue, discussed under the theme of resources in section 6.4) but in respect of confidence, skills and knowledge. In one school, for example, the D&T department was described as outward looking and in principle open to supporting the work of other departments but staffed largely by young and inexperienced teachers who lacked confidence in their own mathematical and scientific knowledge and skills:

> *We don't have the same pressures on us [as the core subjects] – we're much more, as a department, about supporting the curriculum in other areas…What I don't think our department has is confident enough teachers who would take the maths and science forward. We've got quite a young [staff]; quite a new department.*
> (Teacher consultee)

The first round of case study visits to schools identified differing levels of confidence among staff in STEM departments:

> *There are mixed levels of confidence among staff in relation to undertaking interdisciplinary projects. Three or four teachers embrace the idea and are enthused, but there are others who will feel out of their comfort zone. There is a need to offer support to these staff…There's a need for a changed mindset and culture shift.* (Senior leader consultee)

It was suggested that mathematics teachers typically had the least experience of practical work and problem-solving activities and were less likely than teachers of other STEM subjects to make links with other discipline areas. This would mean that mathematics teachers might have more of an adjustment to make and, at least initially, be less confident in undertaking interdisciplinary work:

> *Science and technology can always be taught in applied situations, but maths is not usually done this way in school and can be the 'odd one out'…Maths [teachers] don't necessarily see where they fit in, but science and technology [teachers] will teach maths happily.* (Teacher consultee)

There were, however, some mathematics teachers who were consulted as part of the evaluation who were confident and enthusiastic about undertaking interdisciplinary work and believed they could offer support to less confident teachers. It will be important for schools to capitalise on this enthusiasm.

In three of the schools, **staff turnover has presented a challenge to the delivery and longer-term sustainability of work**, with staff who had initiated or led the STEM work taking on new – and competing – responsibilities within the school or moving on to other jobs elsewhere. Interviewees have emphasised that, where the role of STEM Coordinator or lead is not formally designated or rewarded (an arrangement for which senior leadership support is clearly a precondition), work is likely to drift or disintegrate:

> *It needs somebody to oversee it. Unless you put it into someone's job description it doesn't happen, because there's just not enough hours in the day!* (Teacher consultee)

One consultee also suggested that, to mitigate the impact of staff turnover and to sustain work, there was a need to involve staff within all STEM

departments, and for the induction programme for all new teachers of STEM subjects to be explicit that their individual department is part of the greater whole of STEM:

> *A mechanism needs to be put in place that ensures that, even with a high turnover of staff (there is rapid promotion in science), the links remain. This needs to be part of induction, seeing each individual department as part of STEM.* (Teacher consultee)

Finally, **pupils' interests and availability** also emerged as a challenge. In the case of pupil interest, interviewees noted that extracurricular STEM activity had to compete with other activities, interests and commitments. They also emphasised the considerable demands of the curriculum with a perceived shortage of space in the timetable for additional, creative activity, especially as pupils begin working towards external examinations. As one interviewee framed it:

> *Delivering the curriculum is your priority and you also have pressures from achieving results…It's impossible to take Years 10 and 11 out of school for visits and so on, due to pressures related to exams.* (Teacher consultee)

Furthermore, individual pupils may have additional out-of-school commitments; for example, doing extra GCSEs after school. Schools have largely dealt with these challenges by targeting enhancement and enrichment activity at Key Stage 3 pupils and, in one instance, developing homework exercises.

6.4 Resources

Shortfalls in resources have been consistently cited as a challenge in developing and delivering new work and ways of working. Although the Wellcome Trust grant is acknowledged as a valuable investment, consultees have suggested that it has not been in itself sufficient to secure radical change. **The most critical resource is staff time**, with interviewees indicating that the costs of this were considerable and capable of consuming much, if not all, of the grant allocation. Again, the support of the senior leadership team appears to play an important part in enabling this to happen – or not.

It was noted that this large time requirement was a feature of both curricular changes (e.g. revisions to schemes of work and associated materials) and extracurricular changes (e.g. the development of enhancement and enrichment programmes). Even in schools where supply cover had been paid for, it was thought that the time available was not proportionate to the task. Several schools, therefore, relied substantially on teachers' goodwill, with key staff meeting in their own time:

> *All of the work that has been done has been done in teachers' own time. There isn't funding for a STEM Coordinator post as funding is tighter than ever…so far, the school has relied on goodwill across the teams.* (Teacher consultee)

> *We both have full teaching loads and do not have specific time allocated for planning and meetings…planning and organisation is quite ad hoc.* (Teacher consultee)

> *We have one hour every two weeks to meet and it's difficult to trawl through everything. It will be a long-winded process…[The workload] feels completely manic and frantic.* (Teacher consultee)

STEM Champions – both coordinators or leads and the principal agents of change in the three departments – need protected and synchronised time (unfortunately, something that was relatively rare in the case study schools). In addition, for work to be embedded and sustained, a wider pool of staff need to be involved, including those whose time is already over-committed. As one teacher warned: 'Everyone is so busy with all of their existing responsibilities. We need to be careful that we're not asking too much from staff.'

Although both the organisation of enhancement and enrichment activities and the review of schemes of work were seen as 'front-loaded' tasks, in the sense of requiring a large investment of time in the initial stages, there was an awareness that to some extent the work would be ongoing, with activities and schemes needing revision and updating each year. Interviewees also drew attention to the need for up-to-date equipment and materials, information and advice, which limited funds and time usually prevented them from acquiring.

6.5 Processes

In both phases of the research, interviewees remarked on how processes, often school-wide, could impede change. **The timetabling or scheduling of lessons, topics, examinations and departmental meetings all introduced challenges.**

In some cases, because of a lack of equipment, technology and/or science are taught on a 'carousel' basis. This means that not every class in a year group is working on the same topic at the same time:

> *It's difficult to teach subjects at similar times as science is taught on a rota basis due to lack of equipment. Not every group has the same science lesson at the same time so it's hard to coordinate links between teaching. It's the same with D&T.* (Teacher consultee)

However, it has been acknowledged that this is not an 'insurmountable' problem. Although departments might not be able to coordinate the teaching of common topics, teachers can still highlight relevance to other subjects and remind pupils that a topic has been covered elsewhere (or that it will be in future lessons).

6.6 Integration of STEM subjects

Interviewees drew attention to a relatively small number of challenges specific to the integration of STEM subjects but seemed confident that it was within their capacity to find solutions to these challenges or to work around them. For example, people remarked on the divergent **'language' or terminology** of the different disciplines, difficulties in maintaining awareness of areas of potential synergy in the face of rapidly **changing curricula**, and the importance of providing recognition (and perhaps 'branding') for interdisciplinary work.

7. Future plans and sustainability of STEM

This section considers the sustainability of STEM activities in the eight case study schools, in the short and the longer term. It covers schools' plans for the delivery of STEM in future and compares these to the main features of schools' STEM projects. This is followed by a description of the factors that would seem to support the sustainability of STEM.

7.1 Key findings

Future delivery of STEM

- At the end of the second year of the STEM Initiative, two schools have spent the full grant received from the Wellcome Trust and six schools have funds remaining.
- In the short term, **all six schools with funds remaining expect to use this resource to continue to deliver STEM activities**.
- In the longer term, **six schools expect to repeat or develop activities that have already been delivered**; two of these schools also anticipate delivering additional activities.

Sustainability of STEM

- In two schools, there are no longer-term plans to sustain STEM interdisciplinary activities.
- In the remaining six case study schools, there are indications that STEM interdisciplinary activities will be sustained beyond the lifetime of the STEM Initiative.
- This was particularly true of three schools that had plans to deliver additional activities or included STEM in strategic or operational plans. **Schemes of work had been a key focus of activity in these three schools.**

Factors that support sustainability

The most frequently cited factors considered to strengthen and drive the sustainability of STEM are the:

- level of senior leadership support for STEM
- provision of time off-timetable for teaching staff involved in STEM
- availability of funding for payments to staff or for supply cover
- perception that STEM interdisciplinary activities can support, or contribute to, a school's achievement of its attainment or improvement targets.

7.2 Future delivery of STEM

This section focuses on the future for STEM in the eight case study schools. As Table 7.1 shows, all schools differ in their plans in this regard.

In the **short term**, at the end of the second year of the STEM Initiative, two schools have spent the full grant received from the Wellcome Trust and six schools have funds remaining. All six schools with funds remaining expect to use this resource to deliver STEM activity in the coming school year, 2011/12 (see section 3). Therefore, future activity supported by these remaining funds does not necessarily lead to **sustained delivery of STEM activity** beyond the scope of the STEM Initiative, although in some schools there are plans to also pursue this. Of the six schools with budget remaining from the original Wellcome Trust grant:

- three intend to deliver STEM activities included in their original project plans that have not yet been delivered
- two intend to deliver STEM activities that are slightly different from those originally planned
- one intends to deliver STEM activities but has not yet specified what these will include.

Separate to these plans are schools' expectations of the sustainability of STEM activities in the **longer term.** Six schools expect to **repeat or develop activities** that have already been delivered:

> *I'm repeating [the activity] with the current Year 9 now, after teaching it to Year 10 last year, and in the long term I can see it being taught for Year 9 students.* (Teacher consultee)

> *I will certainly be running a STEM after-school club and it will probably start with [one of the activities previously delivered], they've done a lot of theory, we've got the club in place but attendance hasn't been there because it's the end of the year. But I think the project itself is still quite interesting and the kids do enjoy it.* (Teacher consultee)

> *Our STEM club will continue and the activities for this will develop. I teach BTEC Engineering to a Year 11 class and I'd like to use this as a basis for STEM club activity in future, for younger students and then get the older [Year*

11] students to support some of the younger year groups with the STEM club activities. (Teacher consultee)

Next year we'll have to see how we run things. They will need to be maintained and developed. We'd like to continue and expand our use of the garden area. We had the idea of putting some cameras in the bird boxes, and other garden areas, and maybe setting up a wireless feed, so that the images could be sent to a laptop. (Teacher consultee)

[There will be] further development and implementation of the schemes of work and the STEM club is just going to continue running now. (Teacher consultee)

Only two schools expect to **go further** in sustaining STEM by **delivering additional, new activities**:

There are many more things that we'd like to do. We've got some kit that will help us to run an engineering club. None of us are really engineers, but if we can find a member of staff who is willing to take this on, one has tentatively volunteered, [then] we're hoping to have a mini-engineering club. (Teacher consultee)

Imperial College runs a session on robots for girls, so we're planning to book that session. We're going to start planning for the National Science and Engineering Week right from the beginning of next year. We're planning to use STEM Ambassadors a bit more next year, too. There's the resource there, and we can just tap into it. (Teacher consultee)

From a more strategic perspective, **two schools now have STEM written into either their departmental development plan and/or their School Development Plan**:

STEM is part of our maths and science development plan and it's called STEM in our curriculum timetable. (Teacher consultee)

The STEM stuff has been in the School Development Plan, which is the most important document for the school. STEM is right there, it's in our SDP, so we've got support for it, all the way from the top of the school. (Teacher consultee)

Table 7.1 Future delivery of STEM

Plans for future STEM delivery	Case study school							
	1	2	3	4	5	6	7	8
Spent all WT funding	No	No	Yes	No	Yes	No	No	No
Plans to use remaining funding to deliver STEM activities	Not yet specified	As originally planned	N/A	As originally planned	N/A	Change to original plans	Change to original plans	As originally planned
Longer-term plans to **repeat or develop STEM activities delivered already?***	✗	✓	✓	✓	✓	✗?	✓	✓
Longer-term plans to **deliver additional activities?**	✗	✗	✗	✗	✓	✗	✗	✓
STEM written into strategic plans?	✗	✓	✗	✗	✗	✗	✗	✓

Notes:
*'*Longer-term plans to...*' indicates schools that intend to sustain STEM activities after the Wellcome Trust grant runs out.

Taking a closer look at the features of schools' STEM projects, as set out in Table 7.2 below, schemes of work have been part of the focus of activity in the three schools where the sustainability of STEM is strongest[8] (number 2, 5 and 8 in the table below). The STEM projects in these schools have been delivered by teachers from more than one department and time has been made available for planning and managing this delivery. In addition, senior leadership support for interdisciplinary STEM activity in these schools has been reasonable or strong. Each school has referred to the importance of one or other of these factors in their intention, and capacity, to sustain STEM in the longer term:

> *The time that we've had available to plan has meant that we can take a more integrated view...we couldn't have done that through last-minute planning. It has been good that management have at least acknowledged STEM, and that it needs a working group.* (Teacher consultee)

> *STEM is being delivered as part of the curriculum so I have time on-timetable, through my allocated planning and preparation assessments, to plan what's delivered.* (Teacher consultee)

[8] Based on longer-term plans to deliver STEM and/or its inclusion in school plans.

Table 7.2 Comparison of schools' features and sustainability of STEM

Longer-term plans to sustain STEM	1	2	3	4	5	6	7	8
...repeat or develop STEM activities delivered already?	✗	✓	✓	✓	✓	✗?	✓	✓
...deliver additional activities?	✗	✗	✗	✗	✓	✗	✗	✓
STEM written into strategic or operational plans?	✗	✓	✗	✗	✗	✗	✗	✓
Features of schools' STEM projects:								
Focus of activity	Enrichment	SOW	Both enrichment and SOW	Enrichment	Both enrichment and SOW	Enrichment	Enrichment	Both enrichment and SOW
STEM Coordinator role formalised	No	No	Yes	No	Yes	No	No	Yes
Payment to STEM Coordinator	No	No	Yes	No	No	No	No	Yes
Involvement of teachers from more than one STEM department	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Time available for planning	No	Yes	No	No	Yes	No	No	Yes

- Based on those schools that have longer-term plans to repeat or develop STEM activities or deliver additional STEM activities after the Wellcome Trust grant runs out, as indicated in Table 7.1.
- 'General' represents general support for innovation, creativity and testing out new approaches to engage pupils, of which STEM activities are just one example.
- 'SOW' denotes schemes of work.

7.3 Factors that support sustainability

The main factors that would support the sustainability of STEM closely align with the patterns observed among the schools that intend to sustain STEM in the longer term, as noted above. Perhaps understandably, there is also a strong degree of symmetry between these factors and those identified as key challenges to the delivery of STEM (see section 6).

The **most frequently cited factors considered to strengthen and drive the sustainability of STEM are as follows**.

1. Senior leadership support for STEM:

> *Make sure… that it's valued and seen as a priority by [the] Senior Management Team and other senior leaders. The attitude taken by the school should be: [this is a] group effort and [we are] trying to make this part of the school, bring it into the School Development Plan and make it a priority.* (Teacher consultee)

2. Time off-timetable for staff involved in STEM:

> *It all boils down to time because even where there's a personal interest on the part of teachers who might be new to the school or might've been in the school for ten years, it's the time it always comes down to.* (Teacher consultee)

> *Time – it's always the issue. The school year is challenging, just in terms of doing what you have to do, so anything on top of that time becomes a challenge. That's the biggest barrier.* (Teacher consultee)

3. Availability of funding to support, or to recognise, extra work and for cover:

> *Funding for staff. That really is it. All the other resources are there, in terms of advice and organisation.* (Teacher consultee)

> *For enrichment activities to be sustainable and/or ongoing they need funding for supply cover. The majority of the costs from the Wellcome Trust grant went on supply cover.* (Teacher consultee)

> *All of the Year 7 and Year 8s had a talk by [a scientist who presents TV series], and last year that was funded as part of Science Week by the STEM funding. This year we've part-funded it by STEM and part by the money the school raises through the parents' organisation, so it's half and half. That's*

the kind of sustainability idea we've been moving towards as the STEM funding runs out, in order to keep doing things. (Teacher consultee)

4. The perception that STEM can support, or contribute to, a school's achievement of its attainment or improvement targets also supports sustainability:

If some of the pressure was taken off heads of department in terms of concentrating on Key Stage 4 results, then you may see that happen [i.e. more of the STEM project activities being sustained]. I know the school has plans to move towards more focus on Key Stage 3 and really do something about that. (Teacher consultee)

The headteacher couldn't see the direct link between the STEM activity and the improvement of the school, on the basis of the numbers of pupils who had participated in the STEM project (i.e. not enough pupils were worked with in the past to make a difference to school improvement objectives).
(Teacher consultee)

7.5 Conclusions and lessons

As already noted in the outcomes section, one-off enhancement and enrichment activities are unlikely to have an impact that lasts beyond the initial outcomes they generate. The findings on the sustainability of STEM across the eight case study schools seem to corroborate this finding, insofar as the schools that have predominantly concentrated on delivering this type of STEM activity are generally in a less strong position in terms of the sustainability of STEM. This does not diminish the value of the outcomes already achieved or the commitment, time and energy invested by these schools to ensure their delivery (which, in some cases, has been within a school in which STEM is not a key priority). Similarly, as already noted in the challenges section, this does not mean that the longer-term sustainability of STEM is completely unlikely if, for example, one or more of the challenges faced by such schools is addressed and removed.

However, a closer look at the profile of those schools that intend to sustain STEM once the Wellcome Trust funding has ended indicates there are key choices to be made by schools thinking about introducing STEM interdisciplinary working to their school, both in terms of the focus of the STEM activity and the organisational approach the school adopts in delivering such activity.

The overall conclusion is that **if a school's aim is to introduce interdisciplinary STEM activity to its pupils in a way that can be sustained in the longer term (and progressively embedded in the school's curriculum and organisational culture), then activity focusing on changes to schemes of work is more likely to lead to this outcome**. This outcome becomes even more probable if the activity includes the involvement of teachers from more than one STEM department, a provision of time has been made for planning and managing the delivery of STEM activities, there is a clear plan setting out pupil-focused outcomes or success criteria and details of how these can be measured in the short and long term, and – very importantly – there is reasonable or strong senior leadership support for STEM.

8. Concluding comments

Overall, demonstrably impressive progress has been made by all eight schools throughout the two years of the Camden STEM Initiative. However, there have been noticeable differences between year 1 and year 2 of the STEM Initiative, with progress advancing more quickly and comprehensively in year 1 in all but one school. The momentum in progress slowed in year 2. This was partly a result of the challenges that emerged (some of which had been less pronounced in year 1), particularly those that stemmed from senior leadership support and the time made available for teachers to work together to deliver STEM activities (or the lack thereof).

There is substantial evidence of very effective collaborative and participatory practice in delivering STEM interdisciplinary activities. This includes the delivery of STEM enhancement and enrichment activities (with innovative examples of one-off STEM events), the setting up of STEM Clubs and the use of external speakers. In addition, and very importantly, it includes revisions to schemes of work to bring out the links between science, D&T and mathematics and to support consistency in the delivery of topics that span the three subjects. This all provides valuable examples and learning, which could be shared among other schools in Camden and elsewhere.

Other schools are likely to benefit from the lessons learned through the STEM Initiative, which identify the key ingredients that need to be in place for interdisciplinary STEM activity to be successful. The first of these is the need for a school to provide commitment to, and a profile for, STEM in the wider school organisational structure. The other main lesson is that the delivery of interdisciplinary STEM activity can be successfully achieved using a variety of different activities or resources, from homework exercises that link pupils' learning across STEM to the use of external experts and resources to inform, enthuse and educate pupils about STEM and related careers.

Notwithstanding the lessons learned by schools in terms of how interdisciplinary STEM activity is planned and delivered, the STEM Initiative has led to outcomes for all the main beneficiaries including pupils, teachers and schools.

Some of the most compelling evidence of outcomes for pupils revolves around the improvement in their interpersonal and critical thinking skills, which are transferable to other subjects and provide a foundation for future study at advanced levels and for life and work more generally. Pupils engaged in STEM activities through the STEM Initiative have also gained a greater understanding of how STEM subjects are connected in 'real life' and demonstrate a stronger awareness of STEM careers and which combinations of STEM subjects they require for future study and careers. An increased awareness of the importance of mathematics and an understanding of how it is applied in the real world is notable. In addition, pupils have showed greater interest in further STEM study and careers.

Although no conclusive evidence has been gathered on the impact of these STEM projects on pupils' attainment, these types of activities could support pupils' progression at school through their increased motivation to learn and their increased engagement and interest in the STEM subjects. For interdisciplinary STEM activity to develop and thrive, senior leaders in schools need to be convinced of the value and benefits of embracing interdisciplinary STEM activity in terms of pupil outcomes.

The STEM projects have also led to tangible outcomes for teachers by fostering the development of individual staff relationships across STEM departments, increasing staff confidence to teach their subject in an interdisciplinary way and contributing to a greater understanding of the value of linking the STEM subjects in terms of motivating and engaging pupils. STEM now has a higher profile in schools. For STEM activities to be sustained, it is crucial that the main features of successful STEM practice and delivery (as noted earlier) are hallmarks of any delivery by schools in future. Schemes of work, by their nature, will be embedded in ongoing teaching of STEM subjects as they provide a framework in which tried and tested interdisciplinary STEM lessons and activities can be delivered. Much can be achieved by an enthusiastic and committed STEM teacher delivering STEM enhancement and enrichment activities. However, their capacity to sustain activities in the longer term diminishes without support at key levels in the school and/or without a carefully planned approach that ensures the frequent (i.e. at least termly) delivery of such activities. Frequency of delivery is key in terms of STEM enhancement and enrichment activities to ensure that pupils have opportunities to recall and consolidate the knowledge they acquire and to maintain high levels of engagement and interest.

In conclusion, a substantial amount of impressive and impactful interdisciplinary STEM activity has been delivered through the STEM Initiative in the London Borough of Camden. Every school has developed and progressed interdisciplinary STEM activity and can evidence achievements in this respect. There are reasonable (and in some cases very strong) indications that six of the eight schools will sustain STEM activities beyond the lifetime of the STEM Initiative.

Appendix 1: Details of progress of projects

The progress of projects in each of the eight case study schools, during years 1 and 2 of the STEM Initiative, is described in detail below (after the first school, Acland Burghley, the sections for each school will begin on a new page).

Acland Burghley, 11–18 comprehensive with arts specialism

Year 1

The school planned a range of different enrichment projects, which were delivered as part of an Olympic-themed STEM day for 80 Year 8 pupils and a STEM Challenge Day for gifted and talented Year 9 pupils. These events built on original plans to deliver a science and technology fair including project-based work and access to employers, aimed at pupils learning about STEM careers.

- In the morning of the Olympic-themed STEM day, presentations from several speakers were delivered. In the afternoon, groups of pupils worked on activities that included advertising, making a model ski slope, making a model stadium, and designing and making a model for transportation to the Olympic village. Pupils then presented their work and prizes were awarded.
- The STEM Challenge Day for gifted and talented Year 9 pupils started with a presentation from a STEM Ambassador from the Department of Energy and Climate Change. Pupils then went on to build solar panelled cars, complete a biofuel mathematics task (Bowland Mathematics), debate the pros and cons of biofuels, design and test a sustainable transportation model, and give presentations on their transportation models with prizes being given to the best design.

Initial plans to develop a series of cross-curricular units across science, D&T and mathematics were realised through the development of new schemes of work for Year 9 pupils. The main aim of the schemes of work was to make links between the three subjects, but they were also intended to support the development of skills such as personal learning, enquiry, collaboration and self-management.

In addition, and as part of the plan to raise awareness of STEM activities, the science teacher who coordinated the school's STEM work attended training at the Science Learning Centre on setting up a STEM Club, and an INSET day was delivered to teachers in the technology department.

Year 2

The school delivered:

- A 'Patterns in Nature' day for Year 7 pupils in December 2010. The STEM Coordinator and mathematics teacher organised this activity during lessons in science and mathematics. Twenty-five Year 7

pupils researched examples of patterns in nature, including mathematical patterns such as Pascal's triangle, then drew their own patterns and made their own t-shirt showing their pattern drawing.

- The planned STEM Club for Key Stage 3 and Key Stage 4 pupils at the beginning of November 2010, which ran until April 2011. Pupils participated in a range of activities, including the 'Pringle exercise' from the Science Museum and building products to test how much weight they would support (an activity jointly delivered with D&T). The STEM Coordinator organised a rota for leading the activities so that each STEM department could take a turn in delivering the club's activities on a weekly basis.
- A trip to the Science Museum as part of a STEM Club Science Day for Year 7 pupils, in the summer term.

The school's initial plan to use the funds for payments for a STEM Coordinator and to support a bursary for a sixth form pupil studying STEM, was not taken forward.

Future

The school intends to use remaining monies from the Wellcome Trust grant to deliver further STEM activities in 2011/12.

Camden School for Girls, 11–18 girls' school with music specialism

Year 1

The school's plan to run a disease outbreak week, to initiate cross-curricular links throughout the school (including D&T, mathematics, geography, history, English and IT), was delivered to all pupils in the school. Different year groups attended specific activities on particular days rather than throughout the week. Pupils also attended normal lessons during the week as it was not possible to take them off-timetable. The week included a different theme every day (disease outbreak, health and fitness workshop, disease identification, vaccines, and science fair) and involved representatives from a range of agencies such as the Health Protection Agency, Classroom Medics and higher education. Activities for pupils included a science show, a physics lecture and a science fair, and some pupils visited Wellcome Collection. Bowland mathematics activities were also used during the disease outbreak week to 'warm [pupils] up' and get them thinking freely.

Follow-up activities were undertaken in Year 9 mathematics lessons and related to analysis of the data that had been collected on the spread of the disease outbreak. Pupils benefited from analysing data from a simulated real-life context that they had experienced and they were given freedom in the techniques they used to analyse the data, which was different to normal lessons.

Subsequent activities, which were in addition to the original plan, included the development of a science and art exhibition by Year 9 gifted and talented pupils in lessons and, during National Science Week 2010, a talk to Year 8 pupils about medicine in Roman times by a Cambridge classics professor.

Year 2

The school delivered several activities that were additional to those originally planned, including:

- A Year 9 science project in which Year 9 pupils were tasked with researching a specific science theme, working in small teams of three or four and presenting the results of their investigation in a visual display or demonstration at a Science Fair exhibition at the end of the 2010/11 school year. The headteacher (who previously line managed the science department) and other science teachers judged the results and voted for a winner.
- A Year 8 science-related art project, for which Year 8 pupils made a trip to the Natural History museum for ideas on how to visually represent a science idea or concept. Their results were also put on display during the Science Fair at the end of the 2010/11 school year and judged in the same way as the Year 9 project.
- A talk by Dr Mike Leahy (a scientist who regularly presents TV broadcasts on science and nature) to all Year 7 and Year 8 pupils. This was a repeat of an activity that took place last year, which was funded as part of Science Week by the STEM funding. This year the school has funded

50 per cent of the costs using the STEM Initiative funding and the other 50 per cent using money raised by the school through the parents' organisation.

Science schemes of work were revised, taking account of any cross-curricular links to mathematics. A range of scientific equipment was purchased, including data loggers and microscopes, to update the resources for science and wider STEM learning.

The plan for teachers of STEM to undertake professional development in relation to Key Stage 3 STEM subjects, working together or on collaborative learning in science and D&T, did not take place as originally intended.

Future

The school plans to use remaining monies from the Wellcome Trust grant to: establish links between pairs of teachers in science and mathematics to more closely coordinate the teaching of these subjects; set up an after-school Science Club, which will offer a range of activities to eventually include CREST awards; and deliver a workshop focused on engineering and technology to Year 8 pupils.

Chalcot School, 11–16 school for boys with severe and complex social, emotional and behavioural difficulties

Year 1

In line with the school's initial plan, Chalcot delivered a project focused on producing useable heat and electric sources of energy for the school and used this as the basis for developing and piloting a permanent STEM scheme of work. The STEM curriculum for Key Stage 4 pupils (both Year 10 and Year 11) was completely rewritten (GCSEs were pursued previously) with the aim of increasing the engagement of pupils.

This included units on measuring and undertaking an investigative research project, building a scientific device (Year 10 pupils), and the application of data logging (accredited through OCR).

The new curriculum integrated the teaching of the STEM subjects and included assessment towards the BTEC Applied Science Introductory Course (level 1) single award (for Year 11 pupils) and double award (for Year 10 pupils). The work that pupils undertook related to alternative energies and included lessons focused on wind turbines, solar panels, building a weather station and using data logging equipment. As well as teaching pupils, the aim of the project was to build two working models of a water-heating solar panel and a wind turbine that could be used in school.

As planned, two teachers went on a week-long course at the Centre for Alternative Technology in Wales in August 2010, at which they worked with others to build a wind turbine, and attended a day's training at Edexcel. The school bought materials developed by the Science Enhancement Programme, which meant pupils could make small models of wind turbines.

Year 2

The curriculum continued to be taught to the first cohort of pupils. The STEM activities undertaken by pupils throughout the course of the 2010/11 school year included:

- conducting all the experimental laboratory work to develop materials to capture sunlight to heat water
- completing all the Science Enhancement Programme practical investigation work on the wind turbines, which included building the rotor, carrying out all mathematical measurements to do that and building a jig to enable magnets to be placed equidistantly on the rotor
- work on probability and data analysis in engineering as preparation for the set up of a weather station.

The combined STEM activities for building the wind turbine and the remote weather collection enabled this first group of pupils to gain accreditation for the BTEC Level 1 Mathematical Applications in Engineering.

Future

Chalcot plans to continue delivering the integrated curriculum to Key Stage 4 pupils and, when appropriate, to Key Stage 3 pupils. Pupils will progress

to:

- Building a model for the hot water heating solar panel, including building four life-size working boxes and undertaking material analysis experiments. This will include copper pipe bending, building a box, putting the installation in, putting all the right materials behind the piping and connecting it to a reservoir and a pump. All of this project work could then be accredited to enable pupils to achieve a BTEC (Level 1) in Science, Applied Science Mathematics and/or Mathematical Applications in Engineering.
- Completing the rest of the lessons and activities to finish off the building of the life-size model wind turbine.
- Conducting weather data collection using the newly installed weather data logger. The data logger purchased has functionality to enable it to collect data directly for the school and to access 10 000 other schools around the world to collect comparative data.

Hampstead School, 11–18 comprehensive with technology specialism

Year 1

The school planned and delivered a STEM week in the penultimate week of the summer term 2010. Pupils were not taken off-timetable but undertook the activities during their usual lessons for the STEM subjects.

As part of this week, schemes of work that integrated mathematics, D&T and science were developed for Years 7, 8 and 9 (Key Stage 3). Year 7 undertook activities focused on food (e.g. smoothies), Year 8 on rockets (which was particularly successful), and Year 9 on space and planets.

Several visitors gave talks and demonstrations during the day (throughout the week) and after school, including a representative of the Department for Energy and Climate Change, a civil engineer and a visitor who gave a talk about planets that took place within a mobile planetarium.

Planned activities also included STEM teachers undertaking CPD in June 2010, which was delivered by the Science Learning Centre, and reviewing and testing work from the Nuffield STEM Futures Scheme, which was being released to schools in 2010/11.

Year 2

The school set up a weekly STEM Club, as originally planned, in which pupils undertook a variety of experiments to engage them in STEM. These predominantly focused on scientific experiments, referring to the links with other STEM disciplines where appropriate, and were mostly attended by pupils at Key Stage 3.

It is anticipated that activities delivered to BTEC Engineering Year 11 pupils (as part of the curriculum) could form the basis for further STEM Club activity for younger year groups. A second STEM week was planned but not delivered.

Future

Hampstead expects to deliver another STEM week, which is planned for the spring term 2011/12. Also during this term, the school hopes to deliver a STEM activity using the Greenpower project as a framework, which was identified in the school's original plan as a possible activity for the STEM Club but was not delivered.

Haverstock School, 11–18 comprehensive with business and enterprise specialism

Year 1

As proposed in its original plan, the school appointed three STEM leads across science, mathematics and D&T to form the STEM team, which developed an action plan for their STEM work and began delivering and piloting activities. The action plan focused on the identification of links between the STEM subjects in schemes of work for Year 7 pupils and using STEM homework exercises to make these links clearer.

A Year 7 STEM links overview document was produced and STEM links were also identified in schemes of work for each subject with the aim that teachers would be able to highlight them in the classroom. Teachers were also shown schemes of work for the two STEM subjects that they don't teach so they were aware of what was being taught and when. The homework was specifically written to make links between the STEM subjects. It drew attention to what pupils had learned and the skills they had developed in the three different subjects and gave them a problem to work through. Altogether, six STEM homework exercises were planned – one each half term.

In addition, the action plan included:

- The identification of gifted and talented pupils in more than one of the STEM subject areas to enable teachers to differentiate lessons and target these pupils for additional enrichment activities such as trips, lectures, etc.
- Transition points from Key Stage 3 to 5 and into higher education – STEM gifted and talented pupils and high achievers in STEM subjects were targeted, along with their parents, at various options evenings. Staff also made sure that careers information for the sixth form included STEM careers and that tutors for Years 8, 9 and 11 and the sixth form drew attention to STEM as a career area. The school expected to be drawing on support from STEM Ambassadors to raise awareness of STEM careers to support the transition work.

Other originally unplanned activities included the delivery of a Year 7 competition, in which prizes were given to the first pupils to record that they had heard the word STEM in three lessons, and the set up of a folder on the network drive to share STEM resources among other staff.

Plans to fund at least one day of training for each STEM lead through the Science Learning Centre were dropped to enable the STEM team to spend more time to collectively develop and deliver the action plan.

Year 2

As planned, the school continued work on Year 7 schemes of work, mapped the curriculum content for Years 8 and 9 and wrote STEM objectives into schemes of work to ensure teachers become more aware of how to make the links to the other subjects while teaching their own. As part of this, three STEM projects were delivered, comprising:

- A Year 7 rockets project, which was devised and delivered in lessons in each of the STEM subjects, focusing on a rocket and/or propulsion project. In science, pupils had a lesson investigating the forces involved in launching a rocket, and in mathematics, the pupils had two lessons launching the rockets (using equipment bought by D&T) and measuring angles, collecting data, writing up the results and interpreting their data.
- A Year 8 bridges project, which changed from being a cross-curricular day (when the pupils would usually have science, technology and mathematics on the same day) to a set of lessons delivered in STEM subjects. In science, the pupils had two lessons where they planned an investigation into the materials for constructing a bridge, carried out measurements, and plotted and interpreted their data.
- A Year 9 solar car challenge, which involved a small group of Year 9 pupils designing and building a solar car – which enabled them to get a Bronze level CREST award. The pupils attended the Big Bang Fair to help develop their understanding and support their work on this project.

Several additional activities that were not in the original action plan were also delivered. The Lead STEM Coordinator (science) collated the additional science exercises so that they could be repeated by another teacher, and a group of gifted and talented Year 8 pupils attended a climate change workshop, which enabled them to have a more hands-on experience of the theory they had been studying.

Other activities, additional to the initial plan, related to progression, transition or careers in STEM were also delivered to boost pupils' and parents' understanding of STEM careers, around the time Year 8, 9 and 11 pupils were making their option choices. At the Key Stage 4 options morning for Year 9 pupils and the options event for Year 11 pupils, a presentation was delivered by all three STEM coordinators to explain the STEM careers that are available and what they involve. In addition, a STEM quiz was included in the school diary distributed at the start of the year and displays of STEM information were set up throughout the school.

Future

Haverstock plans to continue to deliver the homework activities developed as part of the revision of the schemes of work for Years 7, 8 and 9, and to repeat the rockets project as part of an after-school STEM Club.

La Sainte Union, 11–18 Catholic girls' comprehensive school with a specialism in science with mathematics

Year 1

As originally planned, the school delivered:

- The 'Garden of Eden' project for Year 9 pupils to teach them about the links between the STEM subjects by designing and building geodesic domes using lightweight and recyclable materials.
- An activity in which Year 8 pupils studied biodiversity by visiting the new cocoon at the National History Museum (NHM). This involved speaking to scientists about how they study and store plant specimens, looking at the interactive displays and attending the Variety Show at the NHM, where they learned about the diversity of life through an interactive science show. In addition, 50 Year 8 pupils visited the Guardian newsroom and learned how to research and write a science story. They then used the latest technology to construct their own front pages, based on their visit to the NHM, which were displayed at school.
- An activity in which Year 10 pupils took part in the Millennium Seed Bank 'Save our Seeds' project. They visited the Millennium Seed Bank, met the scientists who work there and learned that seed banks provide an insurance policy against the extinction of plants in the wild. In an after-school club, ten pupils artificially aged seeds quickly using high humidity and temperature and conducted germination tests to check the viability of the seeds. The ten pupils wrote up and presented this project to external judges and were all awarded British Association Silver CREST awards.

A small group of Year 10 pupils also attended the 'Talking Trees' Royal Institution Christmas lecture in December 2009.

In addition to planned activity, the school organised network events on STEM to which other Camden schools were invited.

Year 2

The Year 9 project was expanded and a vegetable garden was developed for the pupils. Some of the learning from this project is currently being built into technology schemes of work (e.g. in the last week of term, Year 7 and Year 8 pupils picked some of the produce and cooked it in food technology). Other funding was found to employ Global Generation, a gardening company and gardener, to help maintain the garden and deliver planting days. The Millennium Seed Bank project was exhibited at the Big Bang Fair by Year 11 pupils who had been awarded Silver CREST awards. In addition, Year 10 and 11 pupils who attended the after-school club worked on a lichen and air monitoring project.

Future

La Sainte Union expects to deliver the 'Listening to Trees' activities, or other relevant activities such as tree identification workshops, which was part of its initial plan but had been postponed. The school continues to provide a range of enrichment activities and events funded in other ways, wherever

possible, including work with STEM Ambassadors and scientists coming in to give talks. Pupils also go out to talks and events at University College London and Imperial College. In addition, the school organises network events on STEM to which other Camden schools are invited.

Maria Fidelis, 11–18 Catholic convent school with specialisms in humanities and the arts

Year 1

Initially the school planned a project called 'Pupils Tackle Environmental Matters', based on the school rebuilding work expected as part of the government's Building Schools for the Future (BSF) programme. The subsequent cancellation of the BSF programme meant that the school had to alter its plan.

Before this cancellation, the school delivered a STEM day in the spring term for the whole of Year 8. This involved pupils' photos and videos focusing on what they liked and what they thought needed improving in their school and taking part in a Building Schools for the Future workshop, facilitated by Surface to Air, to consider what they thought the science, mathematics and ICT blocks should look like. All of the information produced by pupils was summarised by one of the teachers to inform Surface to Air's future planning.

After hearing of the cancellation of its BSF programme, the school revised its plan to include a STEM activities week. In the summer term, the whole of Year 8 were taken off-timetable to participate in this week, which included three days of activities. The aims of the activities were to make STEM interesting and fun, to raise the profile of STEM and to increase interest in further study and careers in STEM. STEM week included:

- an exercise about shape and structure (based on tetrahedrons) in which pupils built a shelter that they could all fit into
- a presentation by pupils on how they would manage (in) a disaster situation (following on from lessons on natural disasters and their work on building a shelter)
- a building/architecture exercise delivered by an external company, in which pupils were tasked with building the tallest possible structure (skyscraper) using dowels and rubber bands
- a circus science show by a scientist who juggles and does a clown-style presentation (incorporating a unicycle, juggling and magic), which also incorporated scientific principles such as gravity and mathematical patterns, and in which pupils were able to have a go at learning some of the skills themselves
- a mathletics exercise in which pupils undertook a mathematics exercise using a parachute
- a full-day visit to the Science Museum.

A new scheme of work was written for pupils to follow as preparation for this STEM week, focusing on water purification, keeping warm and providing power.

The school also joined the STEM Clubs Network and bought materials to set up an engineering club but, because of staff capacity issues, these clubs were not set up in Year 1.
In addition, a group of gifted and talented Year 8 pupils attended the Big

Bang Fair, and lessons on sustainability were delivered to a cohort of Year 7 pupils using a sustainability kit, which had been given to all Camden schools by a group of architects based in Camden.

The mathematics and science STEM lead teachers attended a lecture at St Mary's University College and one at Hertfordshire University on sustainability and futures thinking. Part of the original plan had included raising awareness of STEM through internal in-service training (INSET), and this was delivered via the set up of a STEM cross-curricular group, which used some INSET time for its meetings.

Year 2

The majority of activities that Maria Fidelis planned to deliver (under its revised plan) had been delivered. In addition, the STEM Coordinator and the Head of Mathematics set up a STEM cross-curricular group of staff who worked together to develop activities using the theme of 'sustainability and environment'. The group have built in STEM links to science for Year 9 pupils and have developed an area of garden into a conservation area.

This conservation area was used to support the delivery of several STEM project activities for 100 pupils during the 2010/11 school year, across Years 7 and 8. These activities included the 'sustainability project' (developed to identify the STEM links across mathematics, science and technology) and a 'rivers of the world' project, a cross-curricular project with art (which was written into science schemes of work). In addition, other classes have used the garden area as part of a regular lesson.

Future

Maria Fidelis will consider how this conservation area can be used to develop further STEM activities (such as studying insects, measuring populations and life cycles, and botany) and write this material into schemes of work.

South Camden Community School, 11–18 comprehensive school with an arts specialism in visual and performing arts

Year 1

As planned, the school appointed a STEM coordinator in D&T and two subject champions in mathematics and science to form the STEM working party. This STEM team explored the best way to deliver the project by reviewing existing schemes of work and exploring opportunities to run collaborative after-school clubs. As part of this planned activity, an after-school STEM Club was set up in the autumn term 2010, aimed at Key Stage 3 pupils and open to anyone who was interested. The scheme of work was rewritten for the Year 7 D&T curriculum focusing on standardising the language and terms used and embedding links between D&T, science and mathematics.

In addition to the initial plan, work also began on revising the Year 8 curriculum in a similar way to both identify and embed explicit, visual links in schemes of work and adapt the resources (e.g. PowerPoint slides) used with pupils.

STEM was included as a regular agenda item at departmental meetings in all of the three subjects, which allowed the three STEM leads to report back to their departments. A dedicated meeting on STEM was also planned for the three departments. The key STEM Coordinator attended a course on Engineering through the Curriculum at the National Science Learning Centre, and the Science Champion attended CPD at the CERN centre in Switzerland (also through the Science Learning Centre).

Additional activities, which were not in the original plan, included the delivery of a range of STEM activities to pupils in Years 7 to 10 in the summer term, including: a Smallpeice Trust activity in which 40 Year 9 pupils built an aeroplane; attendance at the Big Bang Fair in London by approximately 30 Year 10 pupils; a session for approximately 30 pupils in Years 7, 8, 9 and 10 on food hygiene; product development involving a STEM Ambassador; and approximately 20 pupils across Years 7, 8, 9 and 10 building and racing radio race cars as part of the school's creativity week.

Year 2

The Year 7 D&T schemes of work were finalised and prepared for roll out in 2011/12, a Year 8 D&T scheme of work was piloted for one carousel (group), and mathematics and science started work on revising their respective schemes of work.

Other activities and events, additional to the original plan, included: a STEM creativity week, for Years 7 to 10, involving the exploration of STEM through a kite building and flying competition, forensics workshops, building LEGO robots and programming them, and a visit to the Science Museum; a repeat delivery of the radio race car activity; a young engineers' day for Key Stage 3, including a day event delivered by the Smallpeice Trust; attendance at an event at the Institute of Mechanical Engineers followed by a school assembly taken by the pupils who had been to the event; a programme of activity for National Science and Engineering Week, which involved a range

of activities including a ‘fossil hunt’ to Hastings, an astronomy workshop at UCL, and a subsequent follow-up lecture at the school; and a group of Year 8 girls participating in a ‘Robo Girls’ event, learning how to build these robots and programme them.

Future

South Camden Community School plans to train a group of Key Stage 4 and Key Stage 5 pupils as STEM Champions and earn themselves CREST awards by running the STEM after-school clubs for Key Stage 3 pupils.

Appendix 2: Glossary of STEM-related projects, organisations and resources

STEM-related projects, organisations and resources	Description
The Big Bang – UK Young Scientists and Engineers Fair	A national event for young people, celebrating and showcasing the career opportunities available in science, technology, engineering and mathematics. It is free to take educational groups, and there is an exhibition, as well as shows and workshops. www.thebigbangfair.co.uk
Bowland Mathematics	A resource for teaching mathematics at Key Stage 3. These materials are free to UK schools and can be accessed from the website or ordered on a DVD. www.bowlandmaths.org.uk
CREST Award	A projects-based award scheme for STEM. There is a small fee for each student that is registered as working towards an award (bronze, £4.00; silver, £8.00; and gold, £15.00). www.britishscienceassociation.org/web/ccaf/CREST/
Greenpower project	A practical engineering challenge, one of several developed by the Greenpower Education Trust, to increase young people's interest in engineering and their awareness of career opportunities. In 2012, the entry fee per team is £30.00. www.greenpower.co.uk/

I'm a Scientist	An *X Factor*-style competition in which students talk to scientists online for two weeks and vote for their favourite scientist. It is free for schools to take part. imascientist.org.uk
IMeche	The Institution of Mechanical Engineers. www.imeche.org/Home
Imperial College London Outreach days and activities	Imperial College's recent public engagement and outreach initiative, Reach Out Lab (ROL), offers a range of practical, hands-on activities and days in science, technology, engineering and mathematics (STEM), such as: - a theme park modelling activity to explore how to use parametric equations to model complex paths, leading to a theme park ride path (mathematics) - experimenting with electromagnetic induction and resonance in a circuit to design and build a crystal radio (physics) - robotics 'modules', covering topics including: gearing and forces; robotic platform and parts assembly; programming hardware and software options, sequencing and writing; remote control devices; and autonomous programming with sensors.
London Science Learning Centre	Part of the regional network of Science Learning Centres and the CPD opportunities available through there. www.sciencelearningcentres.org.uk/centres/london
Millennium Seed Bank	Based at Kew Royal Botanic Gardens, the Millennium Seed Bank Partnership is the largest *ex situ* plant conservation project in the world. Entry is £10 for adults and free for children under 17. www.kew.org/science-conservation/save-seed-prosper/millennium-seed-bank/
National Science and Engineering Week	An annual week of events and activities aimed at raising awareness of the connections between science,

	engineering and real life, and at encouraging young people to consider careers in these areas. The Big Bang Fair is the flagship event of this week. www.britishscienceassociation.org/web/NSEW/
National Science Learning Centre (NSLC)	A purpose-built facility providing professional development for all those involved in teaching science, in primary and secondary schools and FE colleges from across the UK. ENTHUSE awards are available for teachers attending courses at the NSLC and can be used to pay for course fees, travel and supply cover, accommodation and food, and/or a contribution to support follow-up activities in your school or college. www.sciencelearningcentres.org.uk/centres/national
National STEM Centre	An organisation that leads the UK government's STEM programme and, as part of its resources, holds the UK's largest accessible physical library of resource materials to support the teaching and learning of science, D&T, engineering and mathematics. There is also an eLibrary of free resources. www.nationalstemcentre.org.uk/
Nuffield STEM Futures Scheme	Free teaching resources that challenge students to rethink a future in which humans can thrive in spite of the global threats of increasing population and resource depletion (part of the Nuffield 11–14 cross-curricular STEM projects, which encourage students to develop the skills to explore questions in depth). www.nationalstemcentre.org.uk/elibrary/collection/553/nuffield-stem-futures
Rolls Royce Science Prize	Funded by Rolls Royce, and free to enter, the prize recognises and rewards excellence in science teaching and promotes innovative and sustainable strategies for teaching science. It is open to any school that has participated in a Science Learning Centre course.

	science.rolls-royce.com/home/index.jsp
Science Enhancement Programme (SEP)	Established in 1998, by the Gatsby Charitable Foundation, to develop resources to enhance secondary science education. All of the publications are now available for free on the National STEM Centre eLibrary. www.sep.org.uk/
Science Museum resources	Classroom resources for teaching science at Foundation and all four Key Stages. www.sciencemuseum.org.uk/educators/classroom_and_homework_resources.aspx
Serious About Science	A free annual event for schools that aims to engage and motivate young people to consider science careers. www.seriousaboutscience.org.uk/
Smallpeice Trust	An independent educational charity that delivers hands-on STEM days (£595 + travel expenses), and residential courses for students (£95–£425 depending on the course and the age of the students), well as Teacher Training Days to bring STEM to life in the classroom and their STEM-in-a-box resources (£160 + £10 postage). www.smallpeicetrust.org.uk/
STEM Ambassador	A **free** resource for teachers and schools. Individuals with a STEM background (professionals or experts in their field) who volunteer to support schools to engage and inspire students about STEM subjects. www.stemnet.org.uk/content/stem-ambassadors
STEM Club	As part of the national network of STEM clubs, an extracurricular club that focuses on learning within science, technology, engineering and mathematics. Advice and tips for setting up a STEM club – including ideas for funding support, and activity and project ideas, have been collated at the website: www.stemclubs.net/
STEM Pathfinder School	Forty specialist schools tried out new approaches to

	STEM learning during 2008-09. These schools were known as STEM Pathfinder Schools. Case studies of the work of these schools can be found here www.nationalstemcentre.org.uk/elibrary/file/5356/SSAT_case_studies.pdf Videos exemplifying leading practice in STEM are available here www.nationalstemcentre.org.uk/elibrary/resource/1064/leading-practice-videos
Young Engineers	An organisation which runs a national network of Young Engineer clubs (the club network is free to join and provides resources, advice and activities) as well as national competitions (which are free to enter and aimed at increasing young people's interest in engineering) and STEM challenge days (which cost £550 +expenses). www.youngeng.org/

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