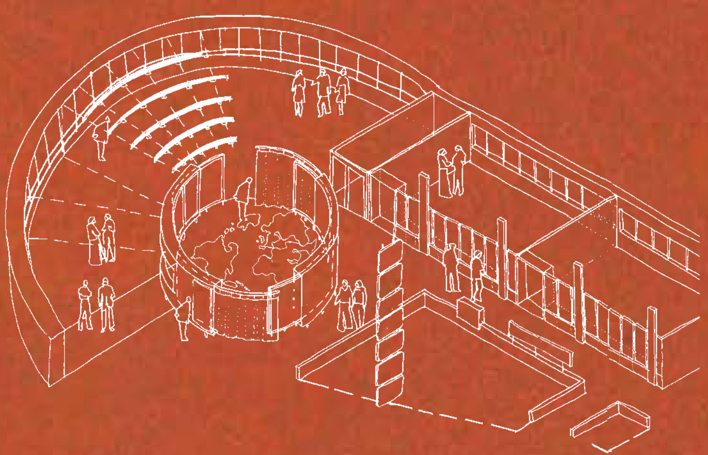
schools for the future

Project Faraday

Exemplar designs for science



department for
children, schools and families

project faraday

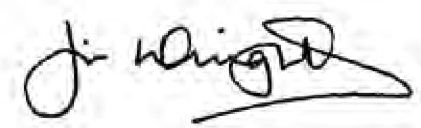
Foreword

Science and innovation are vital to a successful economy and a sustainable future. A good science education is important for ensuring that children and young people not only play a full part in the future world market but also fully understand, benefit from and shape their natural and technological environment.

This is why DfES is working with key partners to implement the Government's commitment to making science a priority in schools at all levels; to improve science learning and teaching and to inspire more young people, from all backgrounds, to study and work in science. Project Faraday aims to improve the design of school science facilities, as part of a wide programme to support these goals. A well designed environment can have a major influence on both staff and students, supporting inspirational learning and teaching.

£6.7 billion of capital funding is available for investment in schools this year. It will rise to over £8.2 billion a year by 2010–11. This includes the Building Schools for the Future and Academies programmes as well as the money allocated to schools and local authorities for their own priorities. This unprecedented investment is a wonderful opportunity to provide schools with 21st century science facilities that support excellent teaching and capture the imagination of students.

I'm very pleased to introduce this book on Project Faraday which showcases exemplar designs for science areas in schools that will be enormously valuable to local authorities, building professionals and schools. These designs result from a close collaboration between designers, educationalists, school staff and students and were guided throughout by experts in science and education. The twelve schools that took part in this initiative will act as demonstration projects for their regions and I am looking forward to the first of these designs being completed and in use by their pupils and teachers at the end of 2008.



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Introduction

Project Faraday set out to promote innovative science facilities that not only support 21st century approaches to learning and teaching but also inspire teachers and learners themselves.

The project is part of a wider Department for Children, Schools and Families (DCSF) programme to encourage more young people to continue studying science beyond the age of 16. It addresses in particular a commitment in the Government's Ten Year Science and Innovation Framework 2004–2014 to "review the Building Schools for the Future (BSF) exemplar designs for school labs to ensure they reflect the latest thinking on what is required to ensure effective, interactive teaching". The project is aimed at schools catering for the secondary age range (11–19 year olds).

A thorough understanding and enjoyment of science at school builds an invaluable foundation for later life. The new secondary science curriculum has been designed to inspire and challenge all learners and prepare them for the future. It engages learners at many levels, linking direct practical experience with scientific ideas. While investigative and practical science continue to be key parts of a student's experience, hypothesising and debating are playing an increasing role.

Science spaces need to reflect this stimulating curriculum, along with the latest developments in a student-centred approach to learning. Inspirational environments can excite students as soon as they pass through the school gates, starting a 'voyage of discovery' that continues throughout the whole school campus.

Project Faraday's main objective was to develop exemplar designs to inform and inspire all those involved in renewing or refurbishing their science facilities, particularly those in major capital programmes such as BSF and Academies. In particular, it set out to deliver:

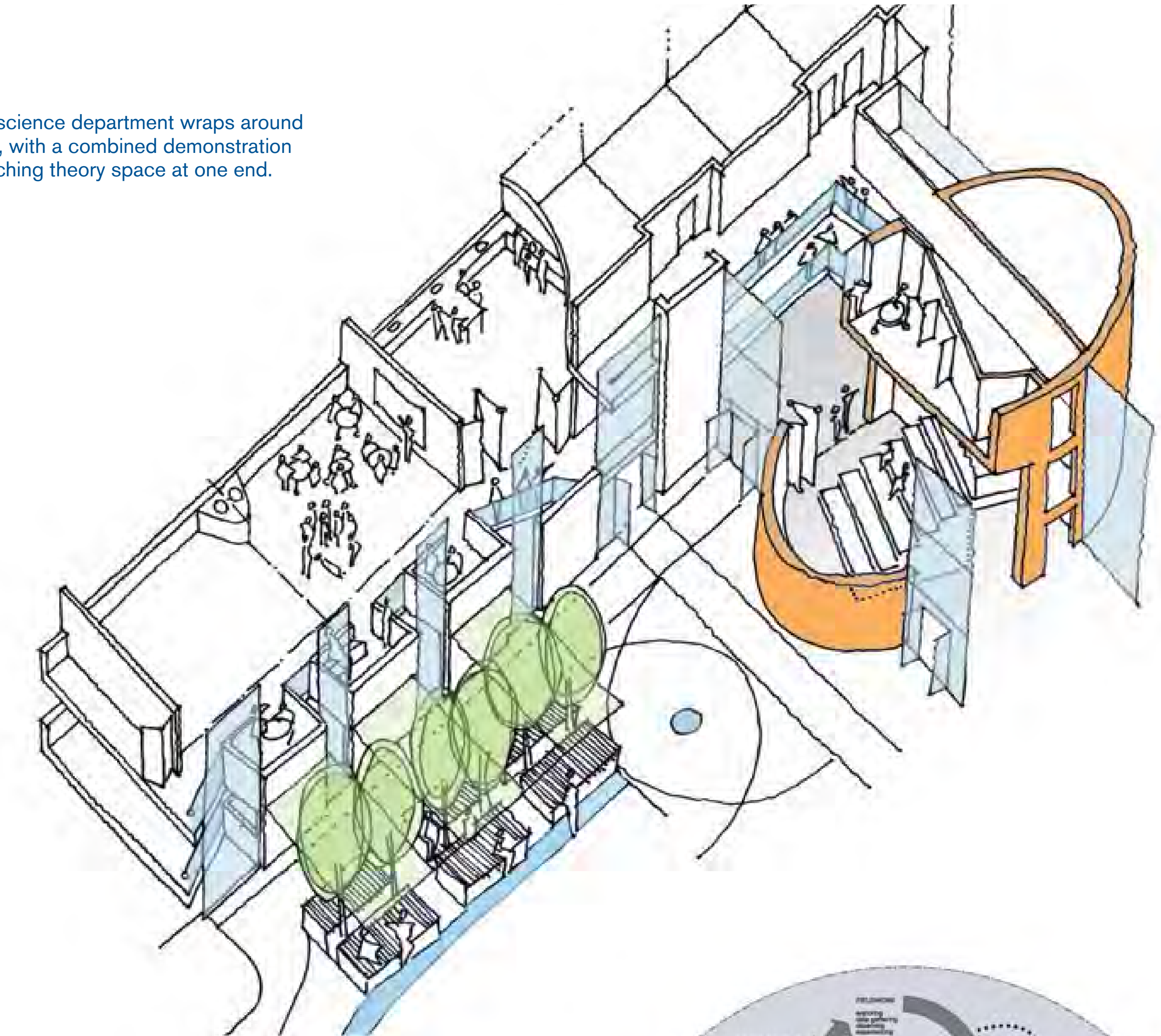
- science facilities in six school renewals
- science facilities in six school refurbishments
- a series of suggested 'interactive experiences', some of which will be installed in the 12 school renewals and refurbishments

Three teams were involved in the project, each including designers, educationalists and construction specialists. Working in collaboration with science and education organisations, they made sure that all aspects of developing new science facilities were looked at in detail. Each team was partnered with two schools that were being re-built as part of the 'One School Pathfinder' programme (part of BSF). The teams were asked to work in partnership with teachers, students and technicians to develop innovative solutions by considering:

- the current and future requirements of their partner schools
- designs that would be practical and affordable for other schools to replicate
- the most effective learning and teaching settings and spaces, including practical work, for example alternative or multi-functional learning spaces
- the needs of individual learners, including those with special needs, and the wider community
- the whole school building and its grounds as places for learning and a learning and teaching resource
- how to fully exploit the latest technologies, including those from other disciplines (such as museums)

Six more schools were selected from regions across England, either to refurbish or extend their existing science facilities. The Faraday teams supported the school refurbishments' existing design teams and provided input from their work with the One School Pathfinders.

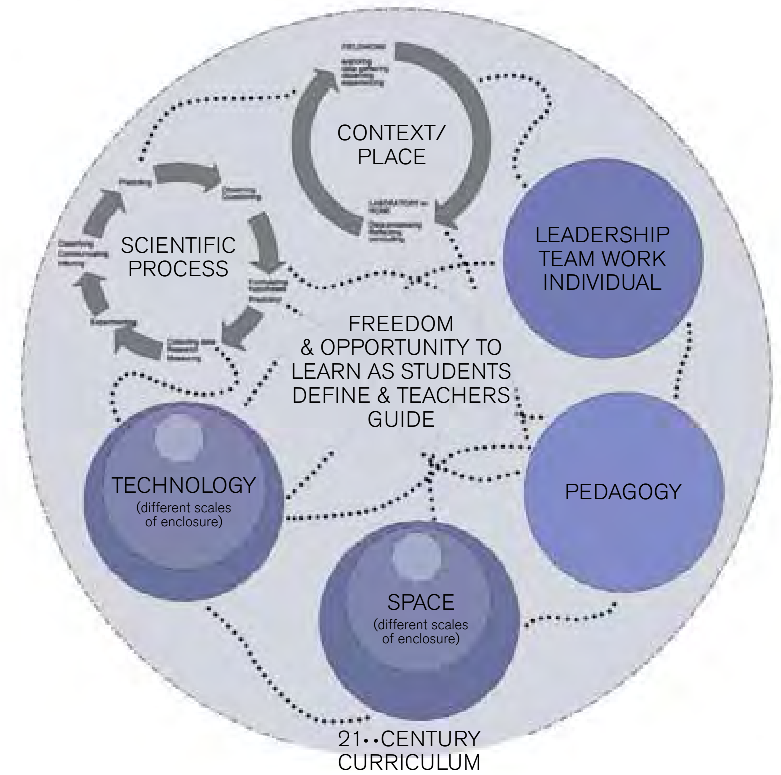
As part of Project Faraday, the teams and schools also had to develop 'interactive experiences'. These would combine tactile learning and/or information technology to create for the whole school practical learning activities which illustrate important science principles. The experiences were to be inspiring and memorable, to fire the imagination even of students who normally show little interest in science.



Bideford's science department wraps around a courtyard, with a combined demonstration theatre/teaching theory space at one end.

As demonstration projects, the 12 Faraday schools will be a valuable resource for their local regions and act as real-life exemplars nationally. The DCSF hopes that other schools and local authorities will visit these schools to see the spaces and interactive experiences in use – but it's equally important to understand the process that the Faraday schools went through to ensure each solution reflects the individual school's needs and budget. Although the process described in this book relates to science, it can be applied equally well to any curriculum area and ideally to the school as a whole, allowing flexibility across curriculum areas.

The first refurbishment demonstration project will be completed at the end of 2008 and the last school renewal in 2010.



Buildings are only part of the equation, and the Faraday teams also had to assess the wider context for their work.

About this book

This book shows exemplar designs for new and refurbished science facilities and interactive experiences, describing the process the teams and their partner schools went through to reach their final solutions. It will be valuable to all those involved in school capital programmes, including local authorities, school heads and governors, and building professionals.

Describes the process followed by the Faraday teams. It spells out a clear plan of action that other schools can follow, from initial research through to establishing a vision, developing a learning and teaching strategy, and finally designing spaces.

Presents the key themes emerging from the project. It summarises the design concepts and ways of working that are common to all the schools involved.

Showcases the designs for the six renewal schools, showing floor plans, furniture layouts and artists' impressions of how the schools will look when they're complete.

Presents designs for the six refurbishment schools, where existing buildings are being reconfigured.

Describes some prototype interactive activities developed by Faraday teams to inspire learners and teachers. These will be trialled in the Faraday schools.

Outlines what the Faraday teams drew from their study trips in the UK and abroad – and may help to show why some of the Faraday designs developed as they did. It may also give readers who haven't been able to study science teaching outside their region an insight into the advances in other parts of the UK and overseas.

Presents the key points from Project Faraday, a discussion of costs, checklists on practical design issues and contacts and references.

The CD-ROM accompanying this book contains detailed information from each Faraday team: brochures and fly-throughs showing the school designs, literature reviews and visit reports. This information is also available on the DCSF Teachernet website.

Section 01

The process

Project Faraday set out to provide ideas and principles that could be adopted by other schools to create accommodation for the 21st century.

One of the core objectives of the project was understanding that the learning and teaching model should influence the eventual designs. All schools going through Project Faraday have different designs, that have resulted from decisions about how learning and teaching will work.

The process outlined on the next pages combines work from the three Project Faraday teams into a logical process. It can be used by schools and design teams to plan their own briefing process for innovative designs that support learning and teaching.

The process

The project adopted an integrated and collaborative approach. Similar approaches may be appropriate for other schools that want to improve science accommodation.

This section summarises the various stages of the Faraday process, giving the goals of each stage (what it aimed to achieve), the tools that schools or designers can use to meet their goals, and the outputs that should come out of the stage.

There were many different tools and techniques used by the Faraday teams, and these are described in the Faraday teams' brochures, which are on the CD-ROM accompanying this book.

The diagram opposite shows that no component of the process should be dealt with in isolation. People engagement, including teachers and learners, is crucial throughout to ensure that each component is planned effectively. Although the Faraday process followed a logical order, with iteration between stages – Research > Vision > Strategy > Practice > Environment – all components must be re-examined when one of them changes, to ensure compatibility. In particular, learning and teaching environment should not be changed in isolation from the other components. If design changes, the other components must crucially be aligned with it.

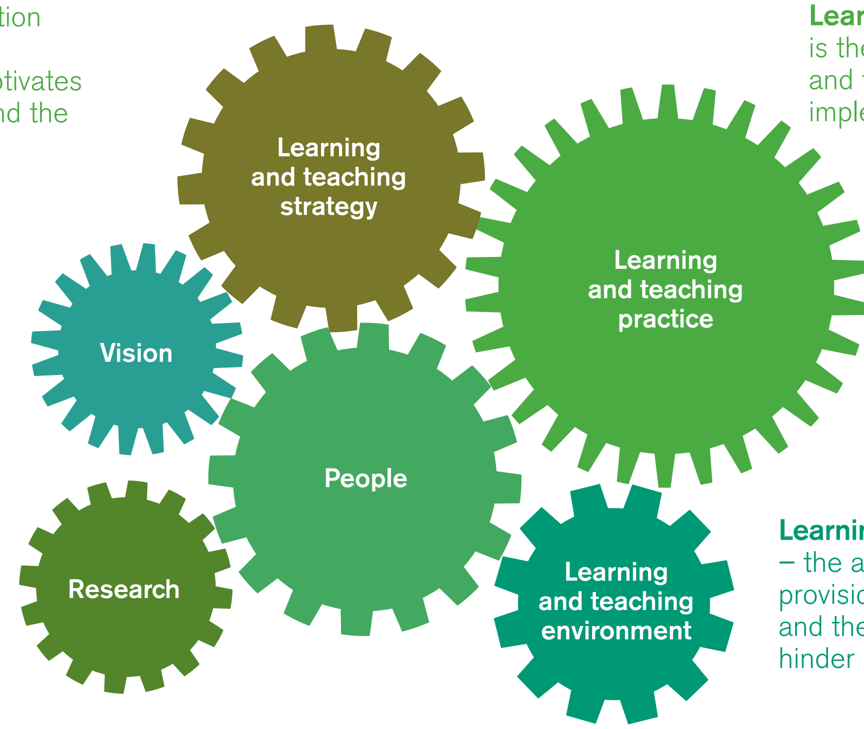
Although Project Faraday was focused on science accommodation, much of this can be adapted to other subjects, and the process would benefit from a whole-school approach (especially in the vision and strategy stages).

Schools that want to use this process should use it as a guide, structuring their own programmes around the different themes. Most of these activities could be done without professional advice, until the space design. But it's highly advisable to put together an integrated team – comprising educationalists, teachers, students and design specialists – as early as possible.

Learning and teaching strategy describes the planning, structures and systems that allow the implementation of the vision and drives the practice.

Vision sets the direction for the strategy to be implemented, and motivates people to think beyond the day to day.

Learning and teaching practice is the day-to-day activity of learning and teaching at the school. It's the implementation of the strategy.



Research provides an opportunity to learn from external sources. Literature reviews or visits to other schools can provide new ideas on learning strategies and design.

Learning and teaching environment – the arrangement of furniture, provision of services and technology and the level of enclosure – can help or hinder people's ability to teach or learn.

People are the lifeblood of the school. This cog combines the culture, attitude and skills of staff and learners that enable learning and teaching to happen. Continuing professional development (CPD) and change management are critical here.

At the heart of Project Faraday were people, the stakeholders who will be engaged with the science accommodation finally created, in particular:

- The learner – Project Faraday was focused on inspiring and encouraging science students. All Faraday teams spent a good deal of time meeting learners at their partner schools to understand how they wanted to learn.
- The science workforce, including teachers, technicians and support staff – the exemplar designs needed to reflect how staff would use the department day to day.

Research has shown that changes to an environment or learning activities are far more likely to be successful if staff are fully engaged with the change process and have training to help them adapt.[1]

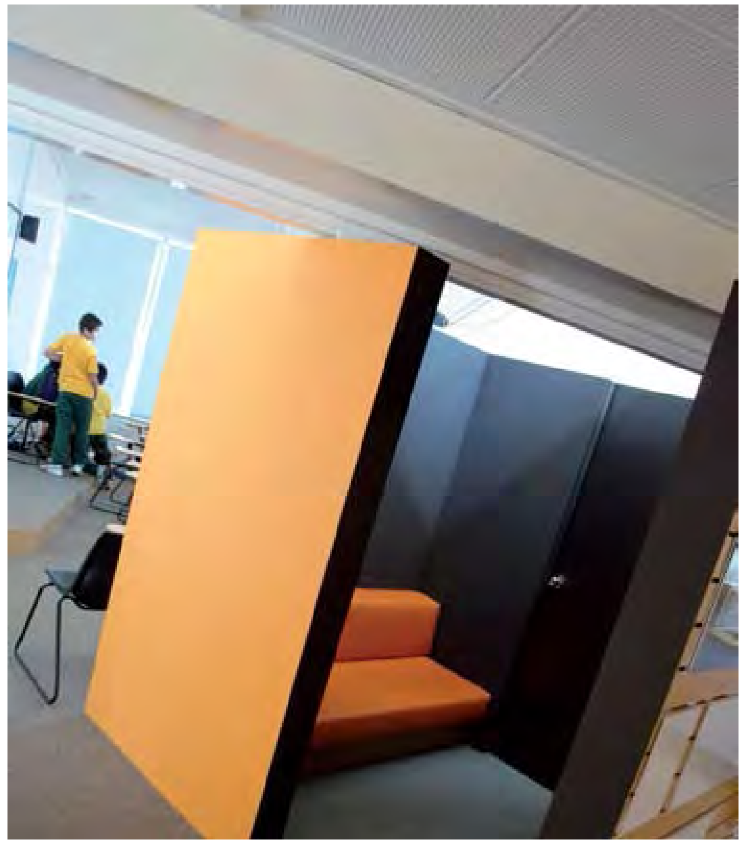
Project Faraday had to be focused on learning and teaching practice, not just on design. It meant making sufficient time for engagement with the school and the local authority. It also meant considering staff training in preparation for the new building. DCSF is considering developing a CPD project in support of this.

East Barnet School takes part in a Lego serious play workshop, explaining abstract ideas about learning science. "What I really want in science lessons," explained one learner, "is to feel like I'm really doing science, that I can get something wrong, think about why that was, and try something different."

[1] For example, research into open plan design found that: "teachers lack specific training for this environment", and there is "little evidence of teachers putting into practice the methodologies open plan was supposed to encourage" (CfBT, undated)

Research need not be an arduous process: it's about equipping your team with the facts before starting to prepare for design, to build a base vocabulary and understanding that other work can build upon.

Reading this book is the beginning of the research process, but outlined here are two more steps that could be useful in building up the knowledge and expertise of your stakeholders.



With small spaces for personal reflection and larger spaces for group activity, Woorana Park Primary School in Australia enables children to make their choices about where they learn

	Literature review	Case studies/visits
Goals	To pull together existing thinking and research to inform the design of spaces for science, and establish a common understanding.	To learn from other schools or environments, and if possible to see, in practice, alternative implementations of learning and teaching.
Tools	The Faraday teams produced literature reviews covering policy, whole campus learning, curriculum, learning spaces, the role of technology, and learning styles. These are included on the CD-ROM accompanying this book.	One Faraday team developed a selection process for evaluating schools to see. All teams produced a visit report outlining the learning points from international visits.
Outputs	A common understanding from key stakeholders of common practice (outside of the Faraday schools).	An understanding of how other schools have implemented learning and teaching strategies, and what could be improved.
Comment	The literature review doesn't have to be repeated by schools or design teams wanting to design science spaces, but they may want to distil key points on both learning and design from the Faraday reviews.	It's valuable for key stakeholders to see new environments, but they need to look beyond the design to different ways of learning and teaching. It's better to visit somewhere with a very innovative strategy, not purely innovative design.

"A man without a vision is like a ship's commander without a destination."
(JC Penney Corporation, internal communication, 1918)

Vision can be an overused term, yet most research agrees that without a vision – a destination for the ship to reach – it's difficult to set in place the route (strategy).

In a change process like Project Faraday, vision is critical in making sure new ambitions are set and expectations are aligned. It's also vital that all stakeholders are involved in developing the vision – students, teachers, technicians, local authority officers and others.

Teams used a large variety of workshops towards this end, to 'deconstruct the current paradigm' or 'reconstruct a new paradigm'. Deconstructing was about enabling stakeholders to discard their current assumptions about learning and space, and how teaching currently takes place. Reconstructing focused on building new ideas and understanding how things could be done differently. A selection of these workshops is listed below, but there's more detail in the individual teams' design brochures.

Workshop examples

Happy/sad game

Students and teachers (separately) in groups draw and name two real students, one who is a happy science student and one who is unhappy in science lessons. Having created these characters, they then discuss what makes them happy or sad.

This is valuable to explore students' basic feelings towards science and what it is that triggers those feelings.

Forced connections

Groups of staff explore how difficult elements of science can be taught in unusual ways and spaces. Small groups collate a list of:

- areas of the curriculum perceived to be difficult to 'teach'
- different artistic media
- existing locations within the school

By selecting random numbers, connections are forced between items in each list and ideas generated for solving problems creatively. For example: how could you teach cell division in the canteen using printmaking? Or how could you teach enzyme excretion in the gym using animation?

	Deconstructing current paradigms	Reconstructing new paradigms/ vision statement
Goals	For stakeholders to begin imagining the possible options and remove constraints or barriers.	To build a new understanding of the possibilities, and state a vision that the school can unite behind and work towards.
Tools	What if?* Happy/sad Forced connections Radical departure Lego serious play Learning impact map Shared belief *See the Faraday team brochures on the CD-ROM for more details on these tools.	Briefing cards* Kaleidoscope Brainstorming Day in the life
Outputs	A sense among the stakeholders that there is the opportunity to do things differently, should they choose to.	A vision statement, ideally: Imaginable – conveys a picture of what the future will look like Desirable – appeals to the long-term interests of stakeholders Focused – is clear enough to provide guidance Communicable – can be explained in under 5 mins
Comment	It can be very difficult to step out of the day-to-day reality of the stakeholders' current situation when you're designing new spaces. This strand is aimed at allowing that to happen to encourage innovative thinking from the start.	This should act as a reference point for the rest of the project, to guide you through decisions about strategy and design. It may continue to evolve, but shouldn't change direction, so it needs to be something everyone is comfortable with.

It's as important to state and work towards the learning and teaching strategy as it is the vision. It's the link between the vision and the day-to-day practice of learning and teaching and includes decisions about all the elements that make the day-to-day practice function, including, for example:

- curriculum organisation
- timetable structure
- size of learner groupings
- whether teaching is a solo, paired or team task
- how students progress through the school
- the role of the teacher

These are all elements that, among others, affect the eventual design, because together they will define how the space will be used. It's important not to make generalisations, like "learning will be personalised", but instead to express what the implications of personalisation would be on these factors.

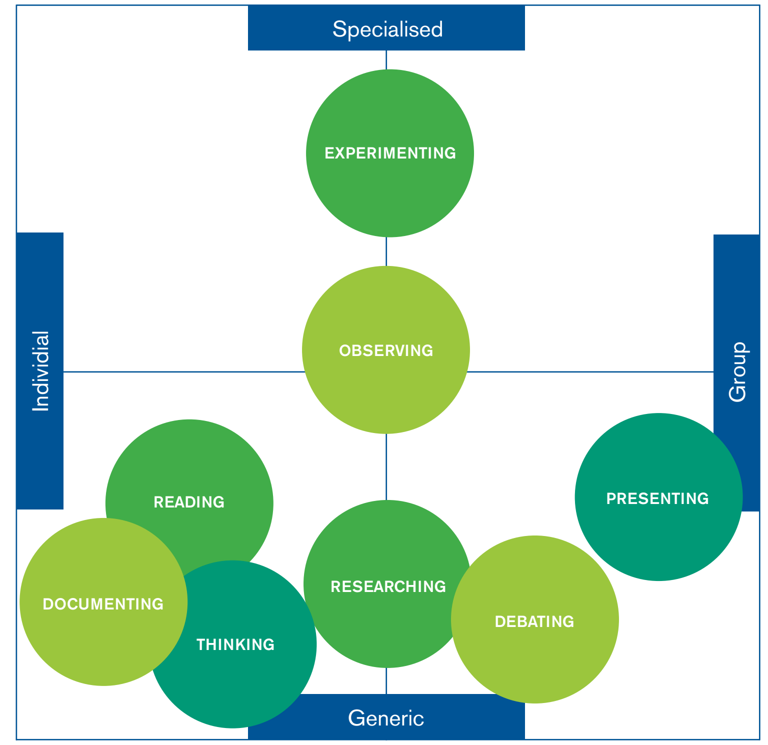
It's also crucial to consider that changes to some factors will affect the whole-school organisation, such as timetable (for example, moving from a six session day to a two session day to support a project-based learning implementation).

Teachers and technical staff need to discuss how learning will be organised before thinking about design.

Learning and teaching practice is the core of the whole learning experience. It's the day-to-day activity of learning and teaching, so the eventual design must support it.

At the research stage, the Faraday teams found that their partner schools' existing science accommodation didn't work for many learning and teaching approaches that were meant to be a core part of the science curriculum. 'Debating' was one example, with staff in one teaching lab, for instance, unable to configure the furniture so that learners could interact well. 'Small group work' was another, where students found it hard to work together in a traditional lab without distractions from other groups. 'Individual study' is similarly very difficult to arrange in traditional science accommodation.

All these findings were fed into the new designs, which were developed from first principles to ensure they supported all the activities taking place within the everyday learning and teaching at the schools.



It's often useful to think about different learning activities in terms of how specialised or generic they are, and how much they depend on group or individual work.

	Organisational model	Curriculum model
Goals	To define the strategic implications of the vision on the basic model of the school, for elements such as curriculum organisation and timetable.	To explore approaches to the science curriculum, including a range of models and scenarios, to establish preferred ways of working.
Tools	The National College for School Leadership has a tool for diagnosing these decisions, part of the Changing Boundaries project.	One of the Faraday teams developed a future scenario workshop where participants ranked various curriculum models and identified levels of transformation they were comfortable with, e.g. student-managed learning, with a selection of sessions to attend.
Outputs	A common, whole-school consensus on the organisational model underpinning learning and teaching, including any changes that need to be made.	A consensus as to how the science curriculum should be approached.
Comment	This is the step that makes a difference in how spaces are organised and what kind of spaces are needed, overall. It's also the most important aspect to consider in terms of change management if the new strategy is different from the old.	It's very important that all strategies are heavily grounded in the curriculum offering taking place.

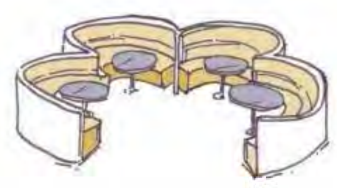
	Learning and teaching practise	Pedagogies or activities
Goals	To define which basic day to day aspects of practise need to change to meet the vision and strategy.	To identify either the core pedagogies that science learning consists of, or activities (such as individual work, group work), or both.
Tools	One team used 'transformation ladders' to define the change, expressing at the top what you want to change, in the middle how you will change it, and at the bottom what it will look like when it has changed.	One team defined eight key pedagogies for science learning: experimenting, researching, debating, observing, listening, documenting, reading and presenting. These can be used as a basis for discussion, or alternatives could be created.
Outputs	A series of ladders that express scenarios to change.	A basic unit to structure the design or settings around.
Comment	For example: Top (what): teachers teaching from the front Middle (how): develop facilitation skills Bottom (final): teacher using a broad range of pedagogies in a lab.	This is an important step to build designs around learning activities, rather than assumptions based on how teaching currently takes place.

The core aim of Project Faraday was to design exemplar types of science spaces to harmonise with changes in the vision, strategy and learning and teaching practice. The teams explored with their partner schools the characteristics of the science learning environment including furniture groupings, services provision, level of enclosure and scale. This led to a range of spaces that are more flexible and better suited to personalised learning than traditional science facilities with labs and labs alone. Additional settings proposed in Project Faraday (sometimes as a space in themselves and sometimes one of many possible settings within a space) include areas specifically designed for:

- small group work (e.g. informal seating around tables, or practical areas for small groups)
- individual study (e.g. 'touchdown' ICT stations)
- large group presentations and discussion (serviced to allow for practical demonstrations)

These new arrangements are achievable within the normal DCSF floor area guidelines.

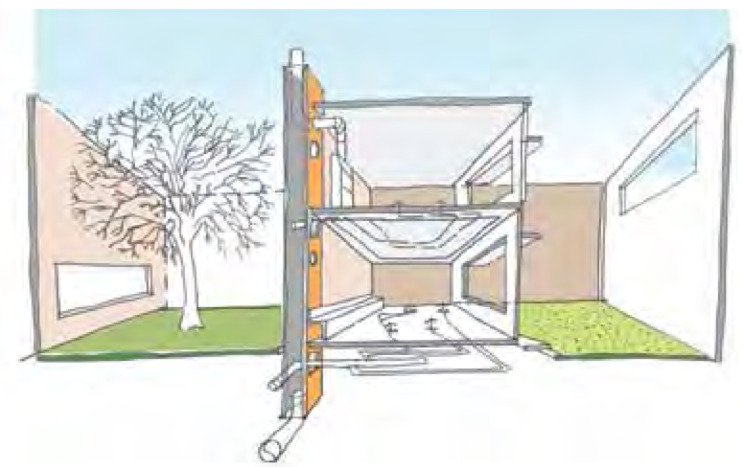
Net area workshop: card may be used to represent guideline areas for 'net' (or usable) area in the school.



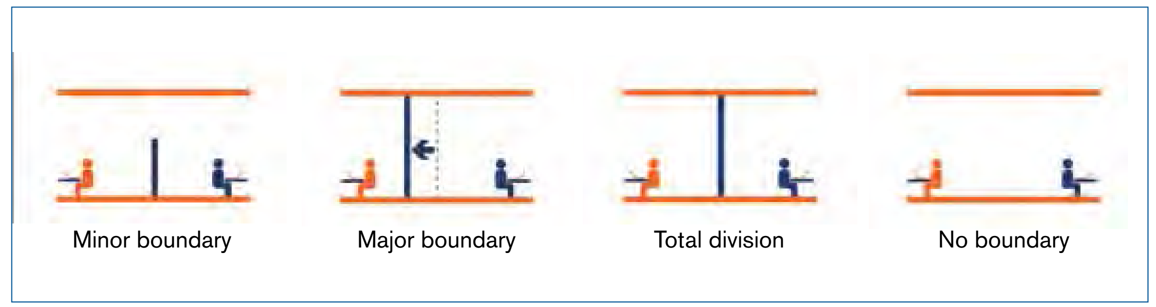
Group work/demo

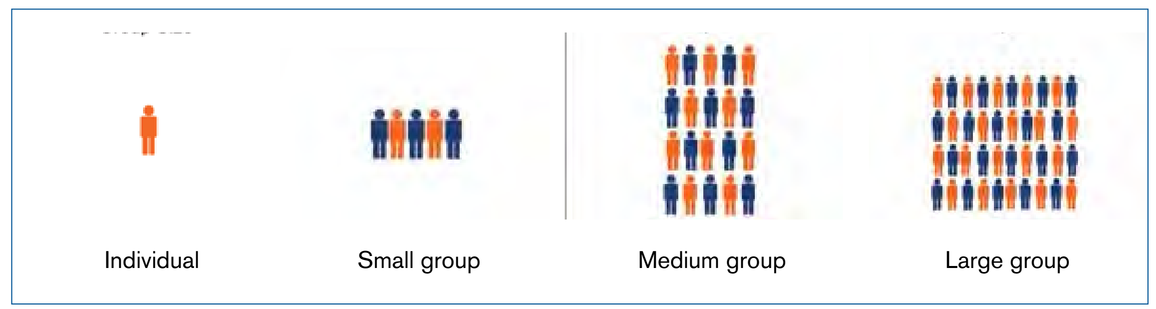
Group experiment

	Net area analysis	Choosing spatial requirements and settings	Space planning
Goals	To consider the overall area allocated for science, taking account of the available budget.	To choose the basic spatial needs of learning and teaching approaches, exploring factors such as boundary control and group size, plus choosing settings that best support learning or teaching.	To plan settings within a space, then explore the concept design and test it against the vision, strategy and learning and teaching practice.
Tools	One team ran a workshop where groups of stakeholders were provided with card, representing the areas suggested in BB98 guidelines. This allowed them to divide area between formal learning space such as labs, and other types of learning settings.	One team developed a 'taxonomy' of decisions (e.g. boundary, learner interaction, and group size). Another team explored scales of science (different opportunities and group sizes). All teams developed a range of settings that could populate science spaces.	This requires expertise from architects or space planners.
Outputs	A model of the preferred departmental organisation within the confines of the total net area. This should be looked at from a whole-school perspective to allow flexibility between curriculum areas.	Some basic principles that will inform the space planning, and decisions on the most appropriate types of settings to support the learning activities defined in the previous stage.	An initial design.
Comment	It's crucial for stakeholders to understand that space can be reallocated within the net area allowance, which is based on the number of teaching spaces needed for the curriculum.	This is an opportunity to explore innovation within space by stripping away assumptions (e.g. that a science space must have four solid walls and be designed for a group size of 30 students), and to select settings that enhance learning.	This is the first step that links with the architectural shell of the building, and it may take many iterations to accurately reflect how the workforce want to manage the science accommodation.



One of the Faraday Teams explored the idea of a family of science spaces. Above left is a lightly serviced lab. Above right is a prep room designed like a pharmacy, and left is a fully-serviced lab.





Faraday teams unpacked the basic characteristics of science settings, like boundaries and group size, to inform their decisions.

Section 02

Main themes

The Faraday teams used a new process leading up to design work, and came up with a series of innovative design ideas.

While each Faraday school was different, and each of the Faraday teams had slightly different approaches, there were clear, consistent messages about the direction of design solutions and the ways of learning and teaching.

This section describes the key concepts and strategies that emerged from Project Faraday. These have been grouped into five themes using common threads that joined the concepts and strategies together.

Each theme is illustrated by examples from the case study schools, which are described in more detail in Section 03 and 04.

Underlying all of the themes is the idea that science facilities must inspire students. This helps students to enjoy science, remember what they learn, and reach their full potential.

Main theme 01

New settings for science

The Faraday designs provide a rich and varied range of settings for science which reflect the schools' inspirational learning models.

The Faraday teams and their partner schools developed settings that would both meet the schools' learning and teaching needs, and inspire teachers and learners. The specific arrangements of space, furniture, fittings and equipment were developed from analysis of learning activities (described in the process section).

The science activities that emerged from the Faraday workshops ranged from 90 people watching a presentation, to one person sitting quietly to consider how to solve a scientific problem. The teams found that, although some practical activities may call for a fully serviced enclosed space (such as a laboratory), there are many science learning activities that can benefit from very different kinds of spaces. By liberating space that may have been used to provide more fully serviced laboratories, other configurations are possible.

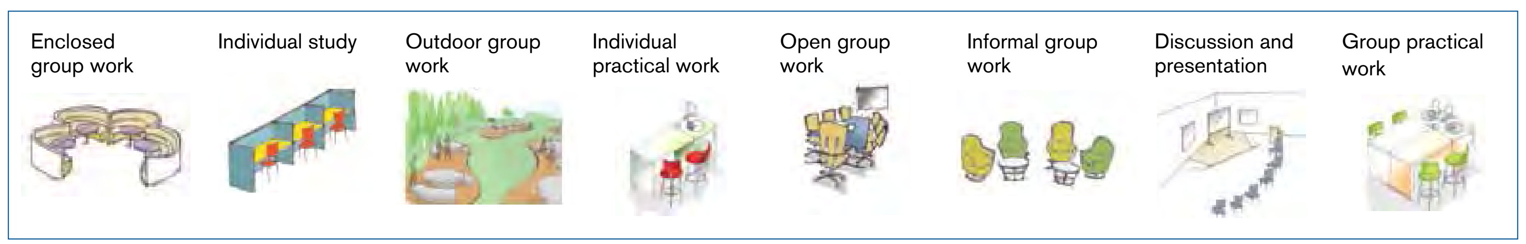
All of the Faraday teams explored differences in scale, inspired by the fact that science itself encompasses every scale from sub-atomic to outer space. They examined the scale of learning groups (from an individual to large gatherings) to the scale of particular areas (from intimate 'thinking pods' to the wide open space of the school grounds).

Each exemplar design has a different range of spaces, reflecting the particular learning model of the school. Typically they include:

- fully serviced practical spaces for a group of 20-30 dedicated to practical work
- lightly serviced spaces for a group of 20-30 involved in a range of activities
- places for large groups (e.g. 100) to gather for presentations or demonstrations
- informal places for small groups or individuals to think and discuss
- open air 'amphitheatres'
- highly interactive areas full of technology/theatrical settings (e.g. immersive)
- outside practical spaces

As these new configurations were developed, a new language or terminology emerged which reflected their function: super labs, studios, theatres, zen zones. Describing settings in this way can help break down preconceptions, making it easier for schools to look beyond their recent experience.

Inspirational learning and teaching can be sparked by a versatile environment empowering teachers and students to use space in different ways.



Settings like these, explored by one of the Faraday teams, can be part of a space or (if enclosed) a whole space.

East Barnet School will have this multi-purpose space, which can be re-organised to accommodate large group presentations.

Cramlington High School will have a glass bio-dome to protect students from the elements when they study plants.

Joseph Rowntree School will have this informal breakout space for reflection and discussion.

Rednock School will have this immersive setting full of ICT for role-play, real life experience and debate.

Three kinds of versatility were explored by the Faraday teams:

- **Agile** – immediate, giving staff and students control over their environment, for example by providing power and data services wherever they may be needed
- **Flexible** – short term, allowing areas to be varied from day to day to suit activities, perhaps by sliding back partitions between two spaces
- **Adaptable** – long term, where building construction and servicing don't restrict changes in response to new learning methods or pupil numbers. The Faraday teams worked very closely with their partner schools to ensure their design solutions meet their current needs and are adaptable enough for the schools' evolving learning models.

All the Faraday designs made highly effective use of the available area – both inside and out – providing a fluid environment that allows different configurations to be combined and spaces opened up. Areas between specific spaces can be seen as 'connective tissue', offering numerous opportunities for impromptu activities.

Faraday has produced inspirational and innovative configurations – but the teams still had to ensure they could accommodate a full range of science activities in safety and comfort. Some of the pragmatic considerations that had to be addressed were safe practical working, adequate acoustic environment in open plan areas, and accessibility for all students, including those with a disability.

The project teams also thought through ongoing maintenance implications of their decisions, ensuring that buildings, grounds and technologies are simple to maintain in the long term.

Inclusion

All the Faraday teams designed with inclusion in mind. For example, DEGW proposed loose tables in all their spaces. Furniture can be moved to support different activity requirements and to ensure clear circulation widths for wheelchair access. DEGW also specified height-adjustable laboratory tables throughout.

Main theme 02

Managing transition and change

Science as a way of understanding the world continues to evolve, and science education responds to this evolution.

Buildings and other facilities need to move forward in step with science education. Changes like those emerging from Project Faraday have to be managed in an integrated way, taking account of processes, people and places.

- Processes – consider current and future learning activities to get the most from new science facilities.
- People – involve staff and students fully in any proposed changes and support them during the transition and beyond.
- Places – design facilities to reinforce the school's current and future learning model (see Process, p10) and be flexible enough to respond to future changes.

All the schools involved in Project Faraday were exploring varying degrees of change in their ways of learning and teaching. They worked with their Faraday teams to create designs that would meet today's learning and teaching needs while having the flexibility and adaptability to meet the science departments' long-term aspirations.[2]• They also had to consider the possibility of the new models being unsuccessful after a period of time and the school moving back to more traditional teaching methods.

All three Faraday teams and their schools were aware that the process of change can't happen overnight – and can only be successfully realised if all staff and students are supported in this period of transition. They typically planned for a continuing process of change, which starts before work begins on site (with teachers trialling a new learning model), carries on when the facilities are complete, and is sustained for several years afterwards.

Well supported gradual change is more likely to be successful, creating a positive environment that new staff and students can adapt to equally well.

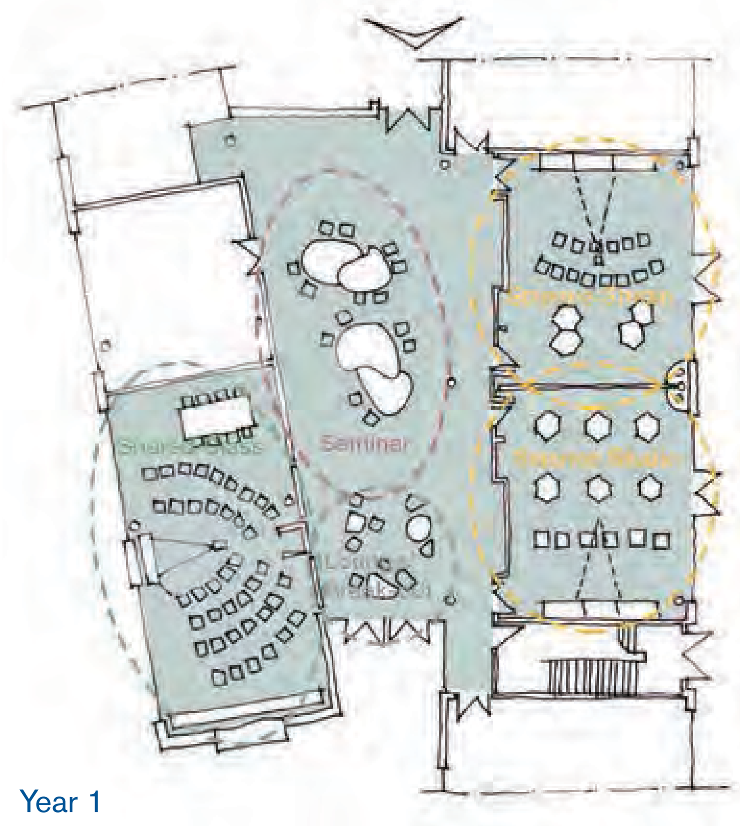
All the Faraday exemplar designs comprise a varied range of spaces that complement each other. They work best when they are seen not as individually owned spaces but as a whole, as 'our space', where staff have shared access and shared responsibility for it. It may mean a change of approach but it can be empowering to everyone, giving staff and students the opportunity to shape the whole science department, and making it easier for staff to share their teaching approaches.

The Faraday schools discussed practical questions like 'Who will maintain shared ownership areas?' and 'Who will move furniture around in flexible spaces?' It's important to agree these matters to get full benefit from shared ownership. A well planned and positive approach to change will make it easier for new staff to adapt to the new way of working.

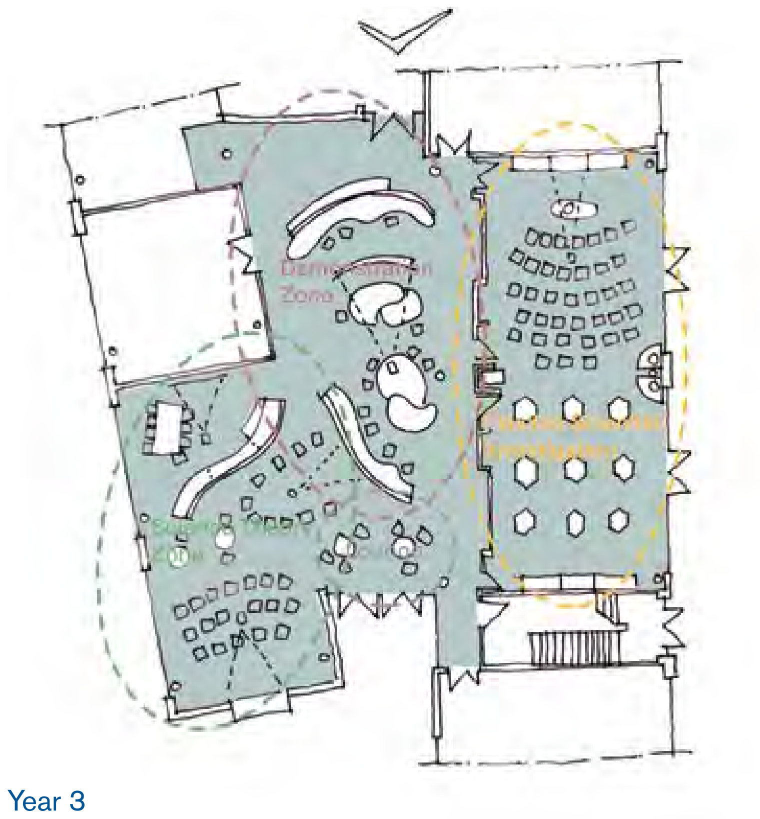
Thinking long term, they also tried to future-proof facilities by making them easy to adapt. One of the considerations was ensuring the school can still function even when refurbishment work is underway.

The Faraday schools planned how their science learning will evlove in future, and built this into their designs.

[2] This is one of the key messages to come out of the government report '2020 Vision' about personalisation in schools.



Year 1



Year 3

Year 7

How facilities can evolve over time

These 'time lapse' plans show how the science accommodation at Joseph Rowntree School will change as the school's learning and teaching strategies evolve. In the first year (top left), patterns of use are familiar to most teachers and students. The studios are mostly used separately, with the occasional opening of a sliding wall for shared teaching on science theory. In the third year (top right), there's greater transformation, with studios open for most of the time and partitions between the classrooms and atrium removed for a large, flexible theory space. In the seventh year, the whole floor becomes an open plan 'learning common', with activities clustered around settings within the space, separated from a central demo area by moveable furniture with ICT docking and areas for writing up.

"If you go round the average science department you see the physical compartmentalisation of the curriculum by subject. In future we will have to take risks – but this means more freedom".

Main theme 03

Getting the most from technology

Technology in science can make it easier for teachers and learners to achieve what they want to do – by releasing their creativity.

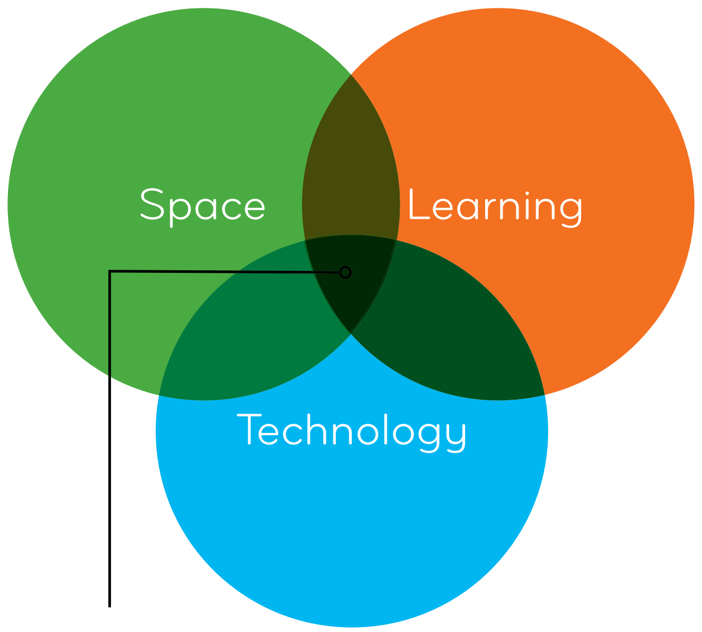
The Faraday teams and schools started from the position that information and communications technology (ICT) is a tool, not a topic. In some cases, they used it to do things that simply couldn't be done without it. They found that ICT can make sophisticated science engagement easier and draw in students who might not otherwise show much interest in science.

The first key point to emerge was that, when you're planning ICT and how facilities will accommodate it, it's better to start by thinking about what you want it to do, rather than rushing into decisions about the technologies.

The second key point was that the Faraday schools integrated space and technology but avoided 'lock-in', so they don't get stuck with outdated technology or inappropriate accommodation simply because it's hard to replace. Integrated project teams (where the architect works with mechanical and electrical engineers, ICT specialists and furniture designers) go a long way towards addressing these issues, and such integration nearly always makes school design more robust.

These schools also recognised that technology has a different lifecycle from a building – replacement times for ICT are often no more than five years. They worked hard to get the infrastructure right, making it versatile and 'layered' so that different parts of the power, communications, computers and peripherals network can be replaced without affecting other parts of the network.

The schools also had an eye on financial and environmental sustainability, considering the long-term cost and energy implications of their ICT decisions.



Focus for design – where space supports learning and is enhanced by technology

Joseph Rowntree

At Joseph Rowntree school there was a major shift in the way ICT was conceived and applied over the course of Project Faraday. The new philosophy aimed to make it ubiquitous and available throughout the school, including in informal learning areas, where it can support students' creativity and independent learning.

Large screens like this can help engage students, but schools should also think about replacement costs.

Digital posters

Digital posters combine real-time live data connection with a traditional poster display to bring home the importance of science in the modern world.

Project Faraday showed that ICT has an important role to play in supporting personalised learning. It can allow students to work through material at their own pace, with different levels of support according to their own preferences. Inevitably, different students will embrace technology to greater or lesser extents and in different ways. The planning for these facilities accepted this and recognised that some learners will use ICT much more intensively than others.

Some of the schools in the project see tremendous opportunities in personal technologies (like games consoles, MP3 players, mobile phones). These can make learning possible anywhere, including outside and beyond the school, and may help make science 'fashionable' among students. There can be risks associated with students using their own equipment – such as the incompatibility between home and school devices, software and connections.

Some Faraday schools are looking at technology to make the best teachers accessible to students anywhere, at any time. This can take pressure off the timetable and can bring in experts on particular topics from other schools. The Faraday designs facilitate this by providing, for example, places where students can listen to podcasts or take part in video conferences.

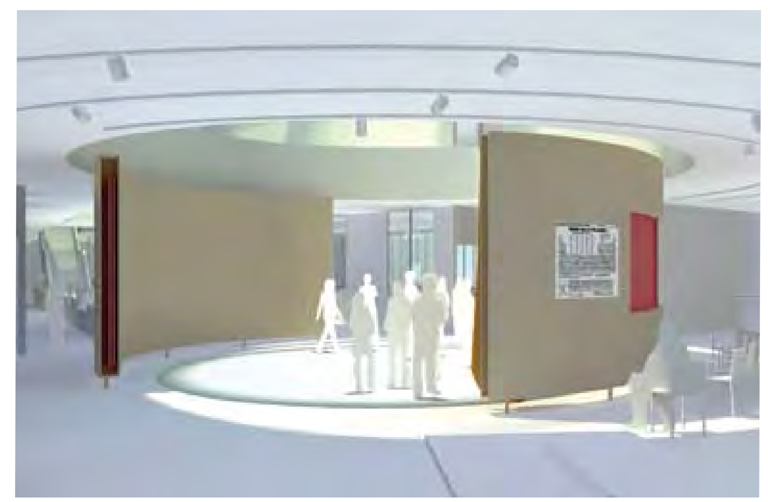
One of the most important ways technology can enhance student engagement with science is by providing direct links to real-time data and the world beyond the lab, transforming abstract and dry topics into concrete experiences. The Faraday teams looked for ways to capitalise on these opportunities.

Three major advances in ICT could offer real potential for science learning in schools, and all have been adopted by some of the Faraday schools:

- Haptic devices – give students a sense of touch when they interact with virtual objects, often in three dimensions. The devices may consist of a stylus attached to a moveable arm, or a glove with instruments built into it, or a mouse that works in three dimensions.
- Immersive technologies – allow students to immerse themselves in virtual environments, often by using novel screens or goggles. These can help make computer-generated situations real to students, and therefore more memorable and engaging. For example, allowing students to fly a virtual plane they've designed themselves, to experience the aerodynamic effects of different wing profiles.
- Mediascapes – sounds, images and video placed around the students. Students use a handheld computer and headphones to see and hear the stimuli, which can be triggered by pointing to locations on a map, or linked to a global positioning system. The mediascapes can enhance students' experience of exploring their school or neighbourhood.

Rednock School

Rednock School will have an incident centre at the heart of its science facilities. Budget permitting, this will be fitted out like a stage set for role plays, with layer upon layer of flexible enclosures and technologies to establish a framework for the school to use in different ways. It will have screens, theatrical lighting and virtual reality facilities, including three-dimensional projection so that the architecture is fully integrated with the technology and the students can immerse themselves completely in their science tasks.



Main theme 04

Science across the whole campus

Project Faraday found that school buildings and grounds can be a vast, real-life resource for science learning.

The whole campus can offer opportunities for students to put their classroom and lab-based learning into context. It can also help to inspire students and underscore the importance of science. The Faraday teams were briefed to look at how grounds and buildings could contribute to learning and teaching, and their designs use the campus in two main ways:

- by exploiting what will be on the sites – building structures, measuring energy use in buildings, natural features
- by creating additional facilities – landscaping the grounds and embellishing buildings to provide learning opportunities

Every school in the project had different, often unique, opportunities for enhancing engagement with science. It was often possible to use school grounds to provide access to a living, changing environment. Some of the most challenging aspects of a site offered the greatest potential.

Where possible, the Faraday schools looked for ways to promote wildlife on their grounds, by creating new habitats, or preserving existing ones. Coupled to outdoor teaching facilities, this will bring science alive to students.

Project Faraday showed that even neglected areas of a school's ground can be transformed into new environments that are both beautiful and help to increase biodiversity.

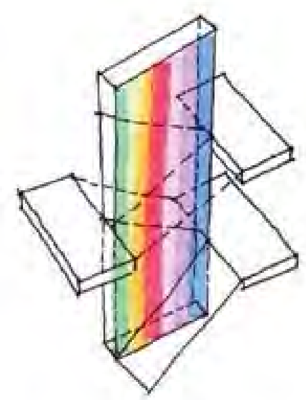
All the Faraday schools wanted to improve the potential for using the outdoors as part of a family of learning settings (See 'New settings for science', p20.) The designs addressed this, blurring the boundaries between indoor and outdoor spaces.

Estover Community College

Estover Community College will have a green roof and a courtyard enclosed by the science spaces, seen as an extension of the internal facilities. It's a living resource for science, with planting areas for students and space for technicians to grow experimental crops.

Rednock School

Rednock School will have a large prismatic partition built into a stair balustrade, which will split light entering through a rooflight and be invaluable for teaching how different wavelengths of light are refracted and reflected in a prism.



A lot of the schools also considered ICT facilities for their outdoor 'classrooms' – in particular power for laptop computers and/or wireless communication links so that teachers and students can access the internet outside.

Many proposals focused on how to make use of a building's structure and fabric as learning resources, making abstract topics concrete. Some schools integrated energy monitoring into their facilities – useful in teaching about the environment, levels of CO_2 and climate change – while others incorporated rainwater harvesting with displays showing how much water is collected.

Many of the Faraday designs support 'kinaesthetic' learning, where students can move around and use their bodies to improve their understanding. For example, one school is using a neoprene mat that students can walk on, linked to a PC so that students can mimic the movement of molecules in gases, liquids and solids. (See p104.) Others are using 'drop zones', where students allow objects to fall several storeys under experimental conditions, using sensors and cameras.

The designers in Project Faraday also used other areas of the school for science learning, building in chance encounters with science artifacts, for example – a fossilised dinosaur, a stairwell designed to look like a rainforest canopy, or slow-run experiments like a drop of tar falling.

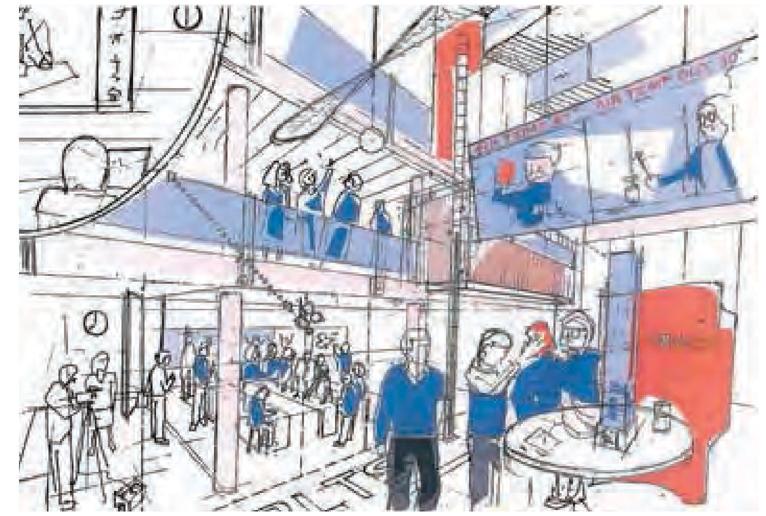
The cross-curricular nature of science will also be capitalised upon in many Faraday designs – especially by using ICT and displays – combining science with design technology or geography for example. But getting the most from these opportunities relies on carefully considering this at the earliest opportunity.

East Barnet

East Barnet will have a Knowledge Garden (below), a living recycling system which allows students to explore the natural world, ecology and biodiversity immediately and continuously. It comprises a constructed wetland which recycles water naturally, without harmful industrial reprocessing.

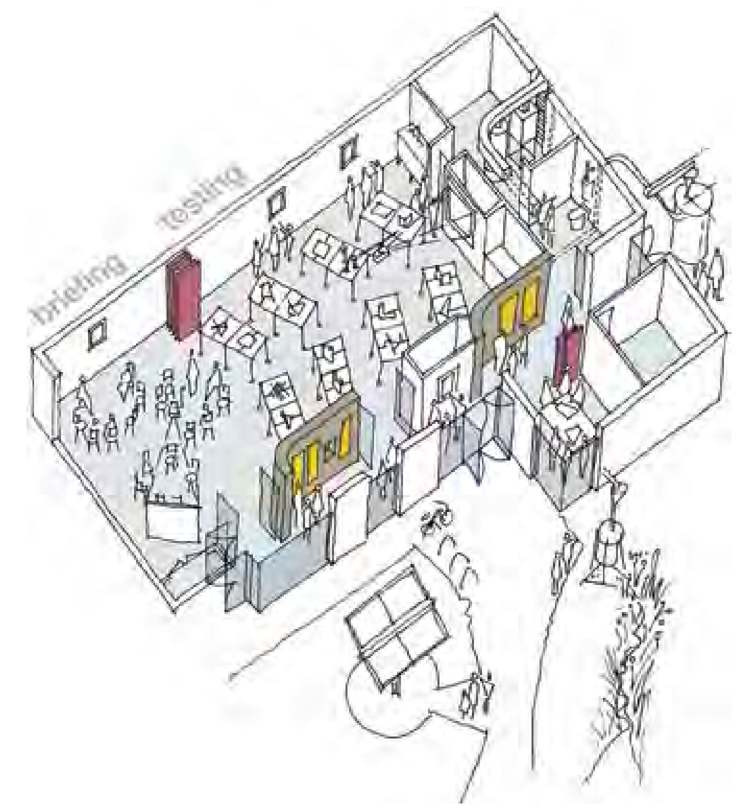
Bideford College

Bideford College (below) has a series of low energy design features and a sustainable drainage system. Displays in the central area show how the building uses energy.



Mary Webb School

The eco-lab at Mary Webb School will be used by students and the wider community to learn about environmental issues. It's been designed to reduce CO_2 emissions and will be equipped with cutting edge technology that will allow students to capture and analyse data e.g. energy use.



Main theme 05

Beyond the school gates

The Faraday Schools are all building bridges with other organisations, garnering unrivalled learning opportunities for schools and partners alike.

School leadership teams recognise the value of working in partnership with other schools. A focus on collaboration enables a school to build additional capacity and capability to maximise the learning opportunities they provide for young people. All the schools in this project collaborate with other schools and various other partners, including local businesses and museums.

Recognising that science accommodation designed today will outlast most current school users, Faraday schools are adopting a custodial approach to their designs, considering not only the role they play in the immediate community but also beyond – and are striving towards science facilities that create a legacy of scientific excellence in education for all. Well designed science facilities can help support the creation of such networks and partnerships.

Faraday schools already use video conferencing facilities to link up with other organisations, including schools, some of them overseas. Some are actively considering starting peer reviews (similar to those widely used in science research), whereby one school reviews the science work of students in another.

Workshops run by the Faraday teams found that students crave direct connections with the real world and the world of work. They showed that students become more involved and motivated in science topics if they use real data – and preferably live data. This makes lessons both meaningful and immediate. An example is using live data from NASA's website to enliven the abstract topic of space science.

Faraday schools also draw on the real world by bringing in outside scientists as new 'learning agents', to give presentations and demonstrations to groups of students. In some cases, the schools plan to use ICT to record presentations so that there's flexibility about when and where they are seen – and to share them with other schools.

Similarly, the schools use some of the highly specialised facilities of their partners, such as photographic developing facilities.

All the Faraday schools are working to involve the local community in their science teaching, encouraging feeder schools and local people into the school to learn more about science. The Faraday designs are flexible enough to accommodate events such as family science days or presentations from external scientists, which can be organised more easily in spaces suitable for large groups equipped for practical demonstrations.

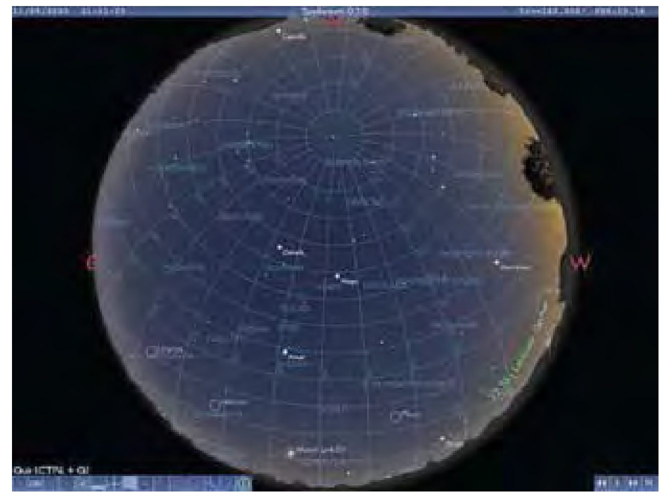
Bideford College

Bideford College has a Key Stage 2-3 coordinator (a teacher) and a 'lab on loan', which goes out to its feeder primary schools.

These arrangements help to build an appetite for science at an early age, and help to cement good links between the primary and secondary schools.

East Barnet

The school's demonstration area provides a flexible space, with moveable furniture and a serviced demonstration bench that can make it easier to bring in outside speakers and/or the local community.



Priory LSST

The school's planetarium (above) will display the changing night sky. This space can become a cinema and will be available to the wider community outside the school – not just for science, but for artists and musicians.

50 feeder primary schools will be able to use the planetarium and extended hours are planned. It will also be used to host the annual Science Day for local primary schools.

Estover Community College

Estover works closely with the Tamar Science Park and can use its specialist facilities. There are also many opportunities for student placements in companies on the science park, which helps to reinforce the message that science is a route into an exciting, dynamic career.

Bideford College also plans to invite professional scientists as guest scientists to present to students.

The DCSF 'Children's Plan: Building brighter futures'

This report, published in December 2007, emphasises the importance of agencies, including the voluntary sector, working together. Many local authorities are already bringing other services onto school sites and BSF is promoting such co-location. Having a health centre or GP's surgery, for example, on a school site is a perfect opportunity for students to link science learning with a real application of science.

Rednock School

Rednock School runs regular family science days, where students' parents are invited in to learn more about science. The school is building on this model through Project Faraday to act as a science hub in the region.

Design proposals:

renewals

Section 03 describes the six design proposals that emerged from the process described in Section 01. These are not necessarily the final designs, because the work continued to evolve after this book was written.

This section describes six school 'renewals' – where new science facilities will be created as part of a whole school rebuilding project. When Project Faraday began, these schools were at different stages in developing their ideas, so the input from Faraday teams varied from project to project. In some cases, for example, the outline design had already been agreed when the Faraday teams made their contribution.

All of the project teams aimed to balance innovation and practicality. They all worked within the budgets schools had available, although as prototypes intended to test new ideas they cost a little more than traditional science accommodation.

The teams took account of DCSF and other school design guidance and all designs are based on the DCSF's area recommendations for the equivalent number of 90m^2 labs and associated prep space. They always ensured that they were designing for inclusion, so all students can benefit from the improvements.

Alongside each of the design proposals is a cost commentary and comments from CLEAPSS. Further information about costs and practical aspects of designing science facilities is included in 'More information', p114.

Faraday teams worked closely with the schools' own architects, but they were never intended to replace them. The designs shown here reflect this collaboration.

These designs should not be seen as blueprints, because every school is different. Instead this work should inspire local authorities and schools and illustrate what is possible.

Renewals case study 01

Abraham Guest High School

A school that blurs boundaries between circulation and teaching space to provide a flexible central area with direct access to an outdoor study garden.

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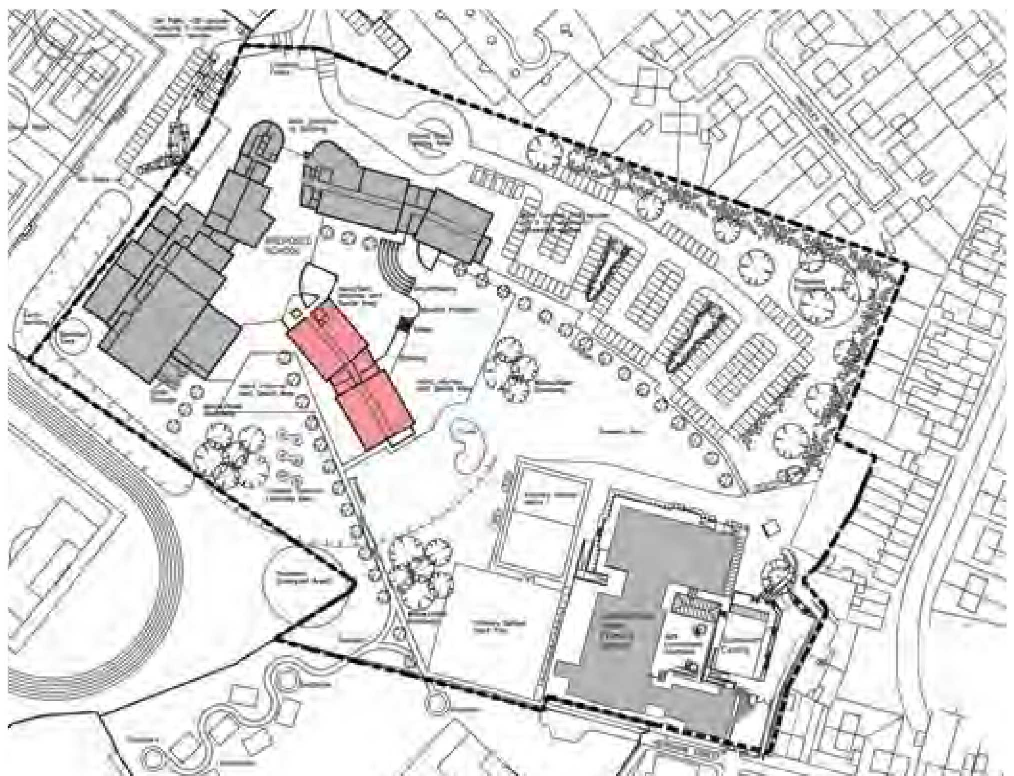
Wigan Council
11–16
DEGW
NPS North West



The site plan shows how the new science block (pink) is positioned to provide wonderful opportunities to connect with the outdoors.

This study garden, bounded on three sides by trees and the science block, will provide space for 30 students to work in small groups.

Abraham Guest High School is a specialist sports and arts college, with a powerful drive to implement personalised learning and make the educational experience more relevant to its pupils. Before Project Faraday, it had already put a great deal of thought into personalisation. For example:

- Deep learning is embedded across key stages, allowing students to assess their own and their peers' progress in different ways.
- It's one of the leading schools in the region for multi-sensory learning.
- Students are encouraged to take account of their own learning.
- It has a varied and flexible Key Stage 4 curriculum (for ages 14+).

Abraham Guest High's science staff are ICT enthusiasts, and the school was the first in the local authority to have wireless laptops and a full complement of interactive whiteboards. The school is also successful in bringing in outside speakers to give presentations to students. Links with industry and universities, as well as an international link to Uganda, have made a significant contribution to science teaching.

The school currently delivers its education in disciplines and wants to retain a science department, grouping all the science facilities together. However, the school's brief was to make this department completely learner-centric, and to use the whole of the area to support personalised learning (here interpreted as: 'individuals or small groups planning activities and then implementing them, potentially doing a wide range of tasks or repeating certain elements until understood').

One of the options that emerged from the Faraday workshops was a half-day structure, allowing learners the flexibility to plan and do various activities without having to stop and go somewhere else to study something different. Teachers would work in teams and the technician's role would evolve to provide further support and mentoring to learners.

The final decision was to provide facilities that could cope with a wide range of teaching styles at once. But, in case this was later deemed not to work, the space should be adaptable and easy to reconfigure.

Fully serviced science labs were intended for practical work only, with learners possibly using them for as little as 15-20 minutes to do an experiment. Theory, demonstrations, research and group work were to happen in other spaces in the science department.

The school and designers took a strategic approach to the brief, to understand the People (learners' experience), followed by the Process (how people learn), followed by the Place (what spaces are needed to support learning). (This is described in more detail in the Process section, p10.) The school and advisers settled on four main objectives for the work:

- Broadening science learning and teaching opportunities outside (using ICT) and ensuring landscape design supports this and links to sustainability objectives
- Building on past outreach events and increasing the links with primary schools and local science organisations
- Developing a demonstration theatre and teaching theory space as non-timetabled spaces, focused on demonstrating science experiments to large groups and making further improvements to the quality of teaching
- Supporting better links with the wider science and non-science community

The school agreed that the ideal learning experience allows learners to find their own pathways, facilitated by science staff, as well as using a broad range of learning styles. This was seen as the best way to engage the current and future generations of learners – and to equip them for 'knowledge economy' working styles.

The organisational model to support this had two notable implications for the space. First, designing a department, recognising that the school might eventually move to an inter-disciplinary model of learning and teaching. Second, providing a wide range of learning spaces to stimulate the maximum number of learning styles and give learners greater choice as to how, when and where they do science in the facility.

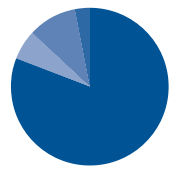
The project team therefore looked in detail at the different teaching methods used for science learning, and defined spaces that could be evaluated by staff and arranged around the site. These different settings were then planned into a layout of zones.

The design team ran a series of workshops to develop elements of the design, including:

- Briefing cards – a specialist tool to engage with students, the science faculty, non-science teachers, and senior management. This improved the school's understanding of its own aspirations for the learning experience.
- Denmark visit – Abraham Guest High School sent two of their staff to Denmark with the design team to look at alternative learning and organisational models.
- Design workshops – with pupils, science staff, technicians and senior management to progress the design to its final stages.

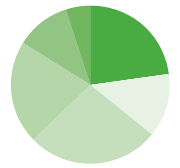
Pre-Faraday schedule of spaces

Space	no.	Size(sqm)	Total
Science laboratory	7	78	546
Small classroom	1	39	39
Science prep	1	30	30
Science prep	1	24	24
Staff work room	1	20	20
Store	1	5	5
Store	1	10	10
			674



Project Faraday initial schedule of spaces

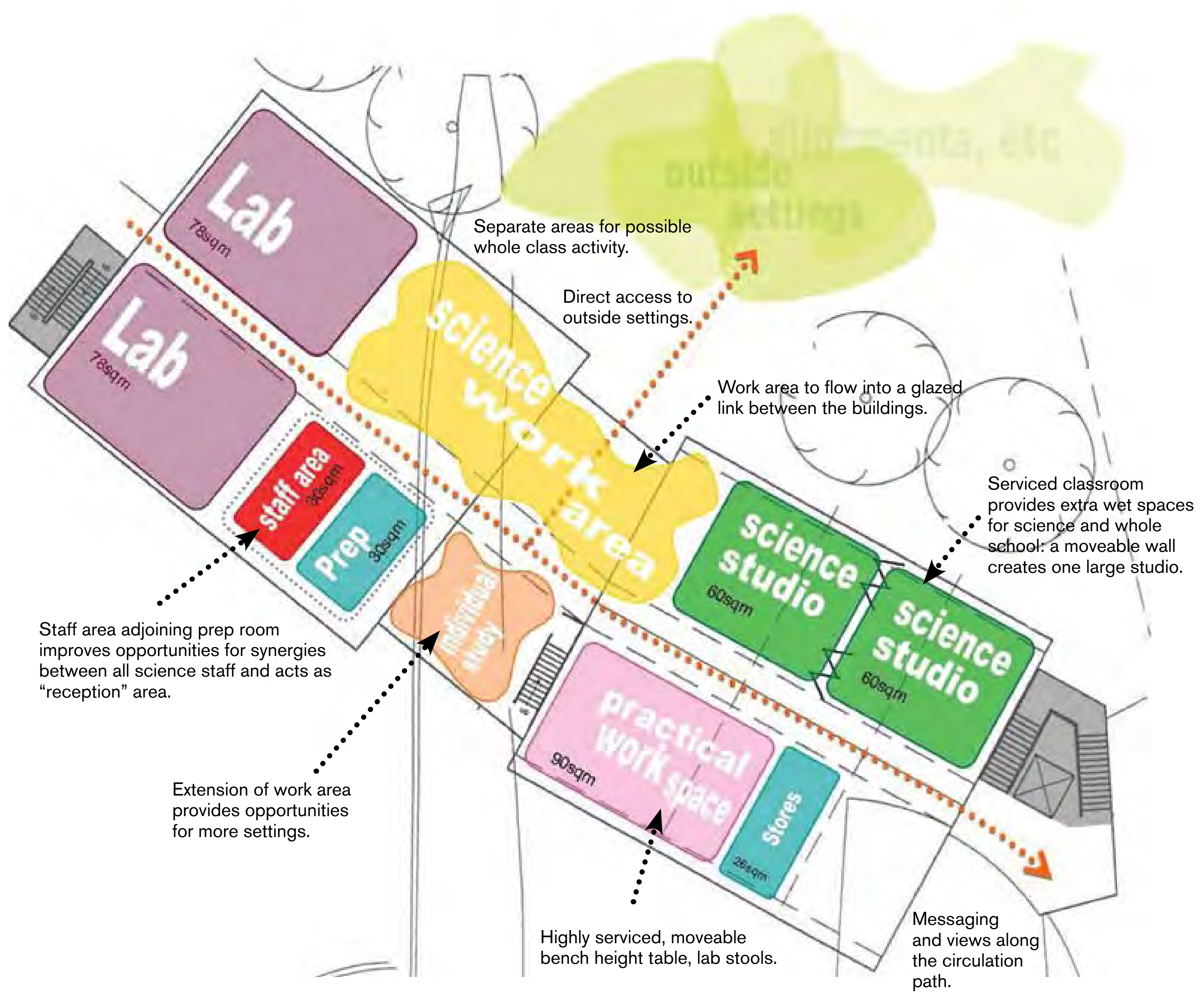
Space	no.	Size(sqm)	Total
Laboratory	2	80	160
Practical work space	1	90	90
Science work area	1	180	180
Science studios	2	72	144
Main prep room	1	39	39
Storage walls	1	6	17
Small prep rooms	1	11	22
Staff space	1	37	37
			689



The original (pre-Faraday) schedule of spaces, based on the school's timetable and pupil numbers, included seven labs of 78m² and one classroom of 39m². Project Faraday work recast the schedule, based on the same overall area, for a much more diverse range of teaching spaces, to meet the school's vision for science. See tables on left hand page.

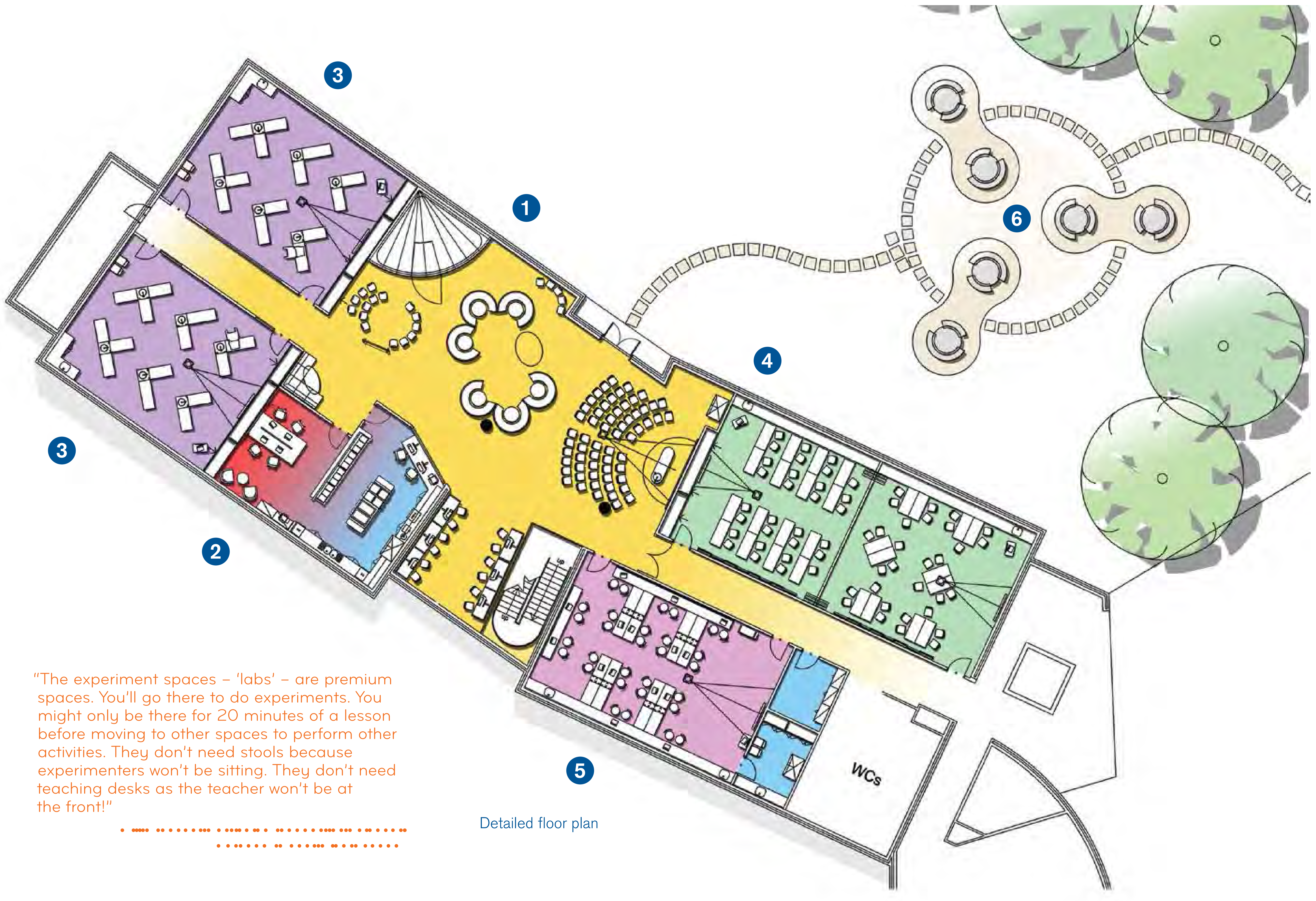
Initial design work included two square blocks of accommodation. These were reworked through Project Faraday to make use of the circulation space between them.

The final design provided five enclosed learning spaces, a staff room/prep area, and one open learning space (equivalent in size to two labs). The school saw learning spaces as the most important aspect in the department, putting less emphasis on storage, so there will be storage walls accessible from the two labs and the science work area.



Concept plan showing key features of the design

The exemplar design provided five enclosed learning spaces, a staff room/prep area, and one open learning space (equivalent in size to two labs).



"The experiment spaces – 'labs' – are premium spaces. You'll go there to do experiments. You might only be there for 20 minutes of a lesson before moving to other spaces to perform other activities. They don't need stools because experimenters won't be sitting. They don't need teaching desks as the teacher won't be at the front!"

Detailed floor plan

1 Science work area (149m²)
Equivalent to two traditional lab spaces, it's intended as the centre piece of the science department, where learners will start and end their learning session.

There's space for presentations to 60 students, with a small, serviced demonstration desk. Behind this, two large group 'snugs' are big enough to seat 15 students per snug, positioned so that a teacher or technician could show a demonstration to an additional 30 students at any time, using a mobile science trolley. The plan shows one arrangement but the furniture can be rearranged to suit different activities.

There's a 'creativity pod' in one corner, where small groups of students can discuss and write ideas on the surfaces. Outside it are soft seats and a mobile whiteboard for group brainstorming.

By the stairs is a series of desks for private study, equipped with PCs and arranged for pairs to research together.

The creativity pod.

2 Staff/prep room (79m²)
The prime welcoming point, with a glazed reception desk onto the main space to handle enquires. The main meeting space has been moved outside the enclosure to provide more visibility and passive supervision, as well as extra space for project groups.

The prep room and staff room are combined so that teaching staff can work closely with technical staff.

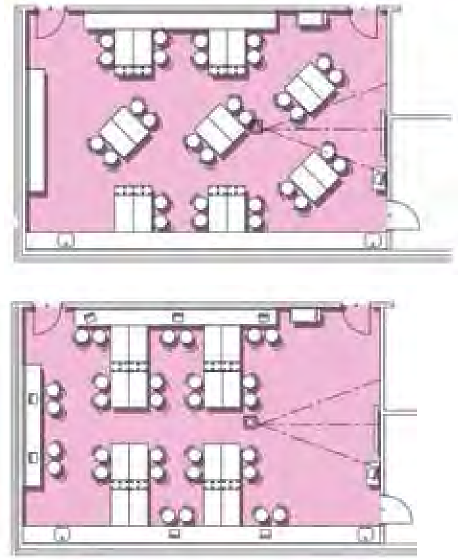
3 Two serviced labs (80m²)
The design team provided a number of options for labs. The school chose the one below where the learners face a direction that's easy to supervise, but without rows (which could feel like a traditional teaching space). Because they are practical-only spaces, they are smaller than normal teaching labs. And because the school had considered in detail how the labs will be used, flexibility is of secondary importance in the choice of furniture, with storage available under the benches.

View of laboratory.

4 Two science studios (72m²)
These studios are larger than those in East Barnet School (72m² instead of 56m², see page 76). This allows lightly serviced workbenches on the perimeter, containing spot sinks.

Large enough for a wide variety of layouts and teaching styles, they have teaching podiums located away from the centre of the studio. The whitewall between the studios can be retracted completely to use the entire space, or closed, when its rotating panels allow ideas to be shared between neighbouring classes.

5 Practical work space (90m²)
Moderately serviced, this space is suitable for group-based experiments relying on collaboration or group work. It's perfect for lengthy experiments, which could be conducted without obstructing the main labs. Serviced bollards are provided, with spot sinks on the benches along the edge. The area near the whiteboard is as open as possible to allow a small group to cluster around the board and discuss ideas.



Alternative furniture layouts.

6 Outdoor setting
The outdoor setting, immediately accessible from the science work area, will allow 30 students to work in groups that are easy to supervise. The tables will be durable concrete, but finished with wood for comfort and good looks.

Cost commentary

- The Faraday team made good use of the space available for science accommodation at the school. The main additional cost items in the proposals are in the central demonstration area: providing the 'creativity pod' and enhanced services equipment and services to maximise flexibility.
- The extra cost of the conceptual design compared to a traditional science facility of 7 labs is £176/m² of the gross internal floor area. This is at the lower end of the range of extra costs identified for Project Faraday renewal projects.

CLEAPSS comments

- At 80m², the labs are below the suggested 90m² for a school science lab, which may limit what changes might be made in the future to furniture arrangements or how the labs are used.
- The design could lead to greater pupil movement than normal – teachers will need to manage this and technicians will need to plan carefully how the labs are supplied with practical materials and equipment.
- CLEAPSS advice is to separate the teacher's area from the prep room for various reasons, including security, separation of preparation and eating and drinking, and the provision of a suitable environment for technicians to carry out difficult and potentially hazardous tasks without being interrupted.
- If there are practical activities in the outdoor area, there should be nearby provision for pupils to wash their hands with soap and water.

Renewals case study 02

Bideford College

A school with a combined demonstration/theatre space that will benefit the school's community and visiting teachers.

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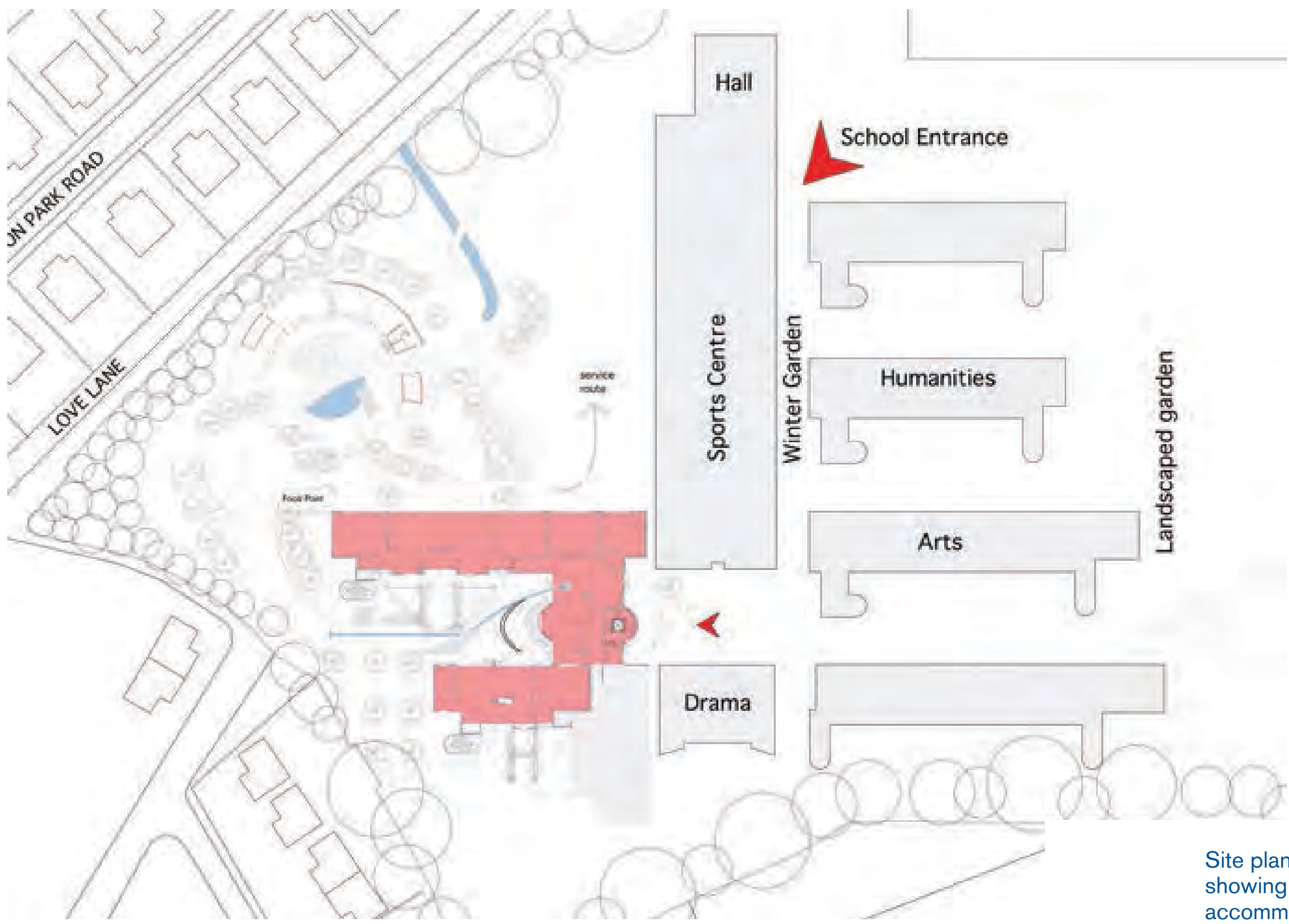
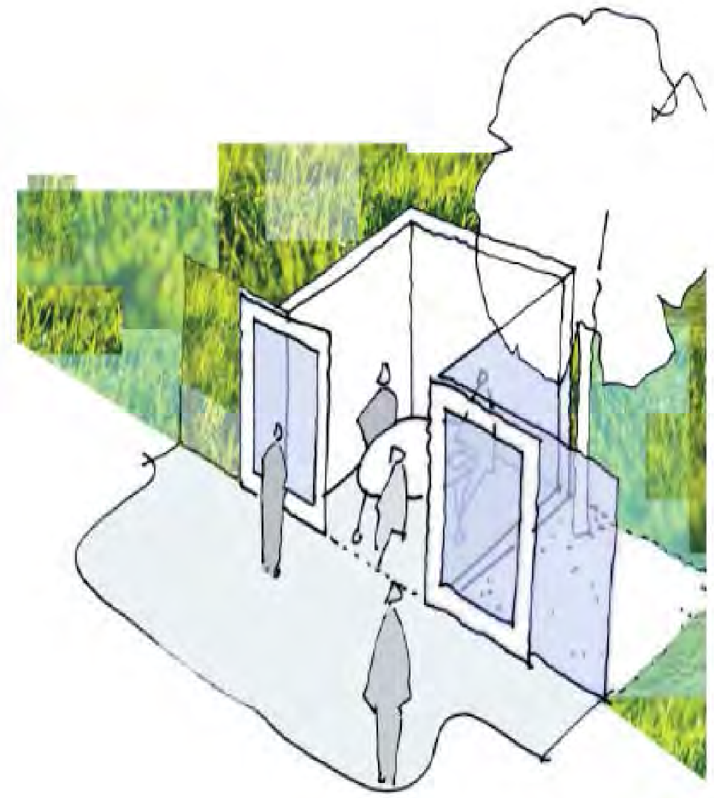
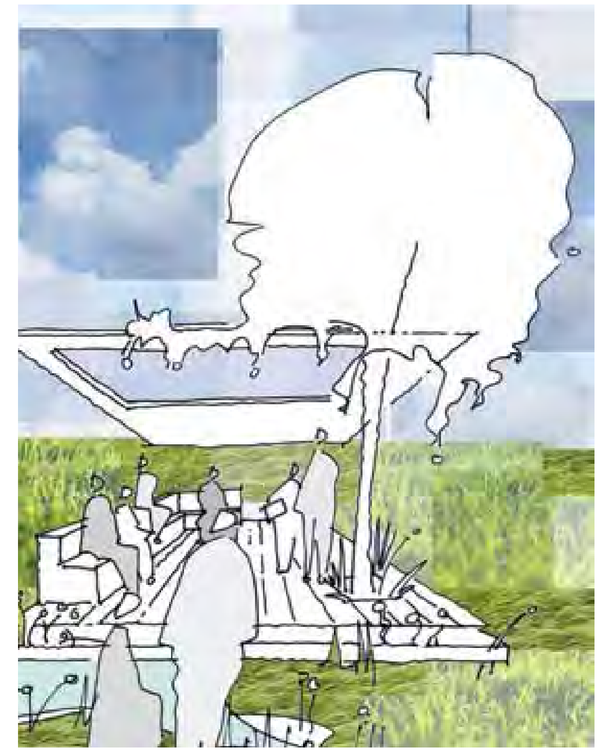
Devon County Council
11-18

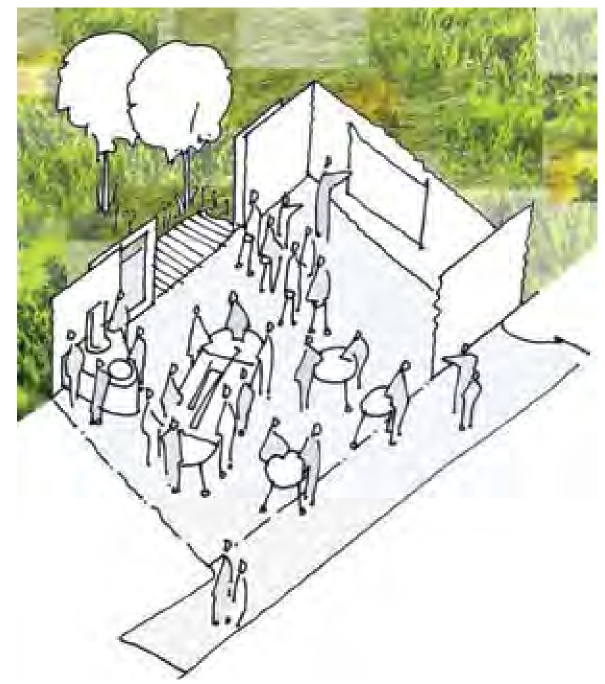
White Design Associates
NPS Property Services SW



Site plan of the new school showing the science accommodation (pink)

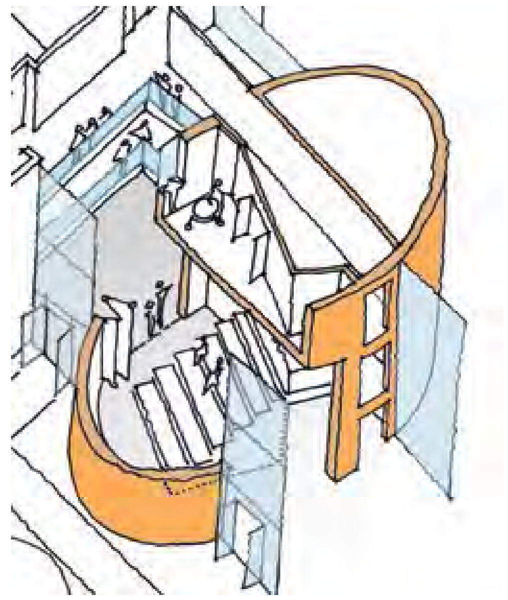






Bideford College is the only science specialist college in North Devon and is a sustainability demonstration school as well as a Faraday demonstration project. The college's science department is involved in leading edge work on primary-secondary transition, through a specialist teacher employed equally in Bideford College and the surrounding feeder schools. The school had started the process of detailed design before Project Faraday began in earnest. Its footprint was therefore largely established and the basic plan of the science department fixed. Project Faraday allowed the school's designers to challenge the conventional breakdown of spaces, at the same time working out how individual rooms would be used, how they would relate together, and how they would be equipped for science teaching. These designs are conceptual designs – proposals continued to evolve after this book was written.

"If science is all work, work and no practical stuff, it's 'Oh no not science again'. We should turn it into something which is really physical and fun."



The demonstration space is on two storeys and allows for raked seating. It opens out onto the teaching theory space for large-scale experiments.

Bideford College puts great emphasis on collaboration – both internally and with those outside. Internal collaboration means science is often taught through other subject areas. This is part of a vision for science learning that centres on the contribution applied science can make to using scarce resources carefully, managing environmental issues and creating a sustainable future.

The college also believes collaboration is a powerful mechanism for promoting deep learning for students, supporting the school's student-centred approach. The college has a 'lab on loan' for use in primary schools and runs training sessions for local primary school teachers, as well as occasional science weeks for feeder schools.

Early discussions with the college sketched out four critical elements for the new building, which formed the basis of a design brief:

- Extending science learning and teaching opportunities outside (using ICT developments) and linking to sustainability objectives
- Building on past outreach events, increasing the links with primary schools and local science organisations
- Developing a demonstration theatre and teaching theory space as non-timetabled spaces, focused on demonstrating science experiments to large groups and making further improvements to the quality of teaching
- Designing to support better links to the wider science and non-science community outside the school

These elements shaped the research stage of Project Faraday at Bideford College and provided a common thread and purpose.

The Faraday team worked with Bideford College to develop a generic suite of spaces and apply them as appropriate within the context and programme constraints. The spaces were developed around specific principles:

- Challenging the definition of a traditional lab and looking at alternative spaces that can support current and future science learning and teaching, with an emphasis on personalised curriculum and project-based learning that engage students effectively
- Promoting flexible interfaces between internal and external spaces, with single-sided circulation that ensures good levels of daylight, passive ventilation and external views/contact for improved sustainability
- Providing spaces that can accommodate today's curriculum while allowing for future curriculum developments and 'transformation'
- Encouraging external learning and teaching in a range of landscape settings
- Breaking down barriers between young people and adults using the science spaces to encourage positive learning behaviour

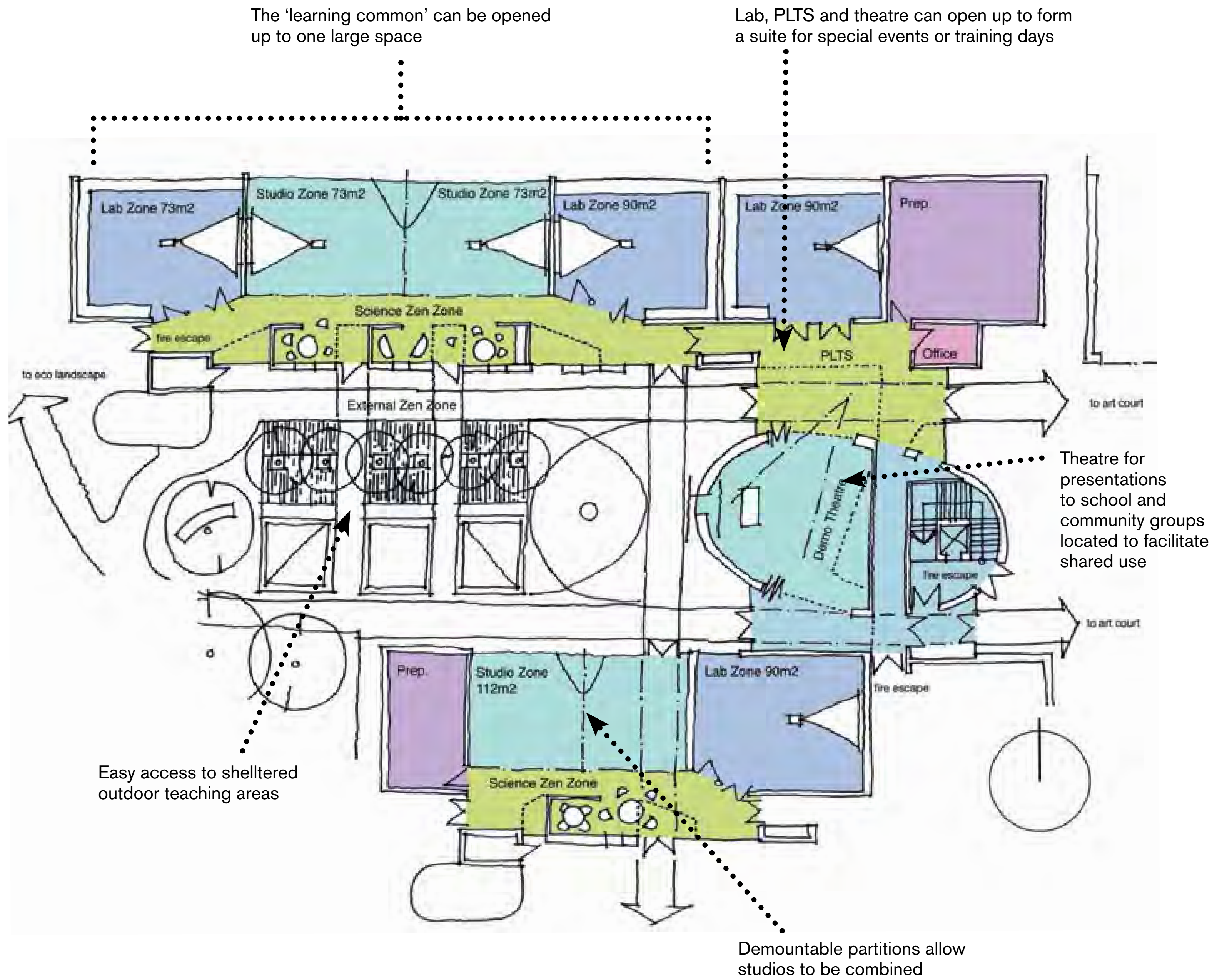
The team also developed a new taxonomy, a way of naming and organising science spaces to reflect the range of learning environments where science can take place. This was useful both for designers and the school in imagining what the science department would look like and how to talk about new science spaces.

The core elements of the Bideford Faraday proposals are a demonstration theatre/teaching theory space, and 'learning commons' – combinations of:

- two fully serviced labs
- two lightly serviced studios
- classrooms
- 'zen zones' (small breakout areas)

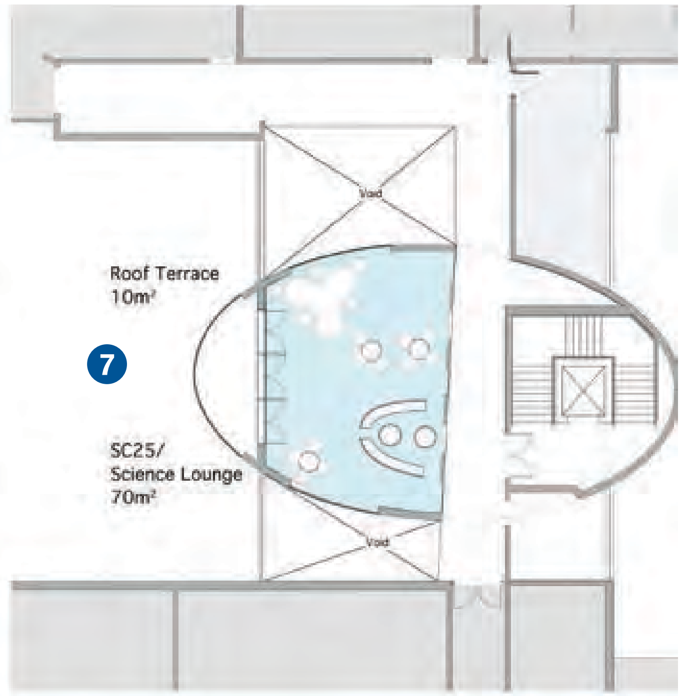
The learning common is equivalent in area to four labs and circulation space in a traditional science facility. The 'common' can be viewed either as a single space with integrated circulation, or as a series of separate spaces.

There are also preparation spaces, staff work areas and a science lounge. How they fit into the broader science facility is shown in the plan on pages 45-46.

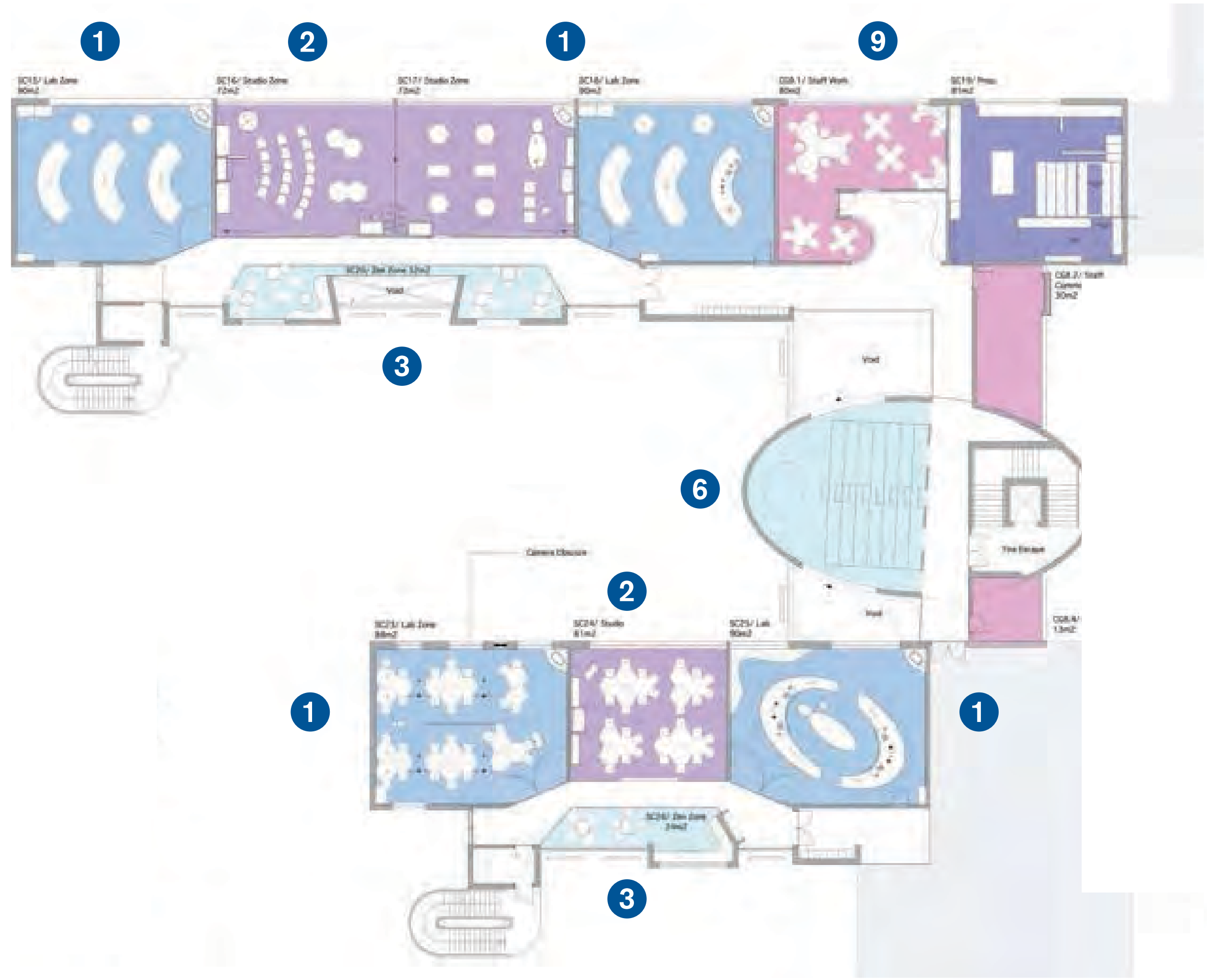


Concept plan showing key features of the design

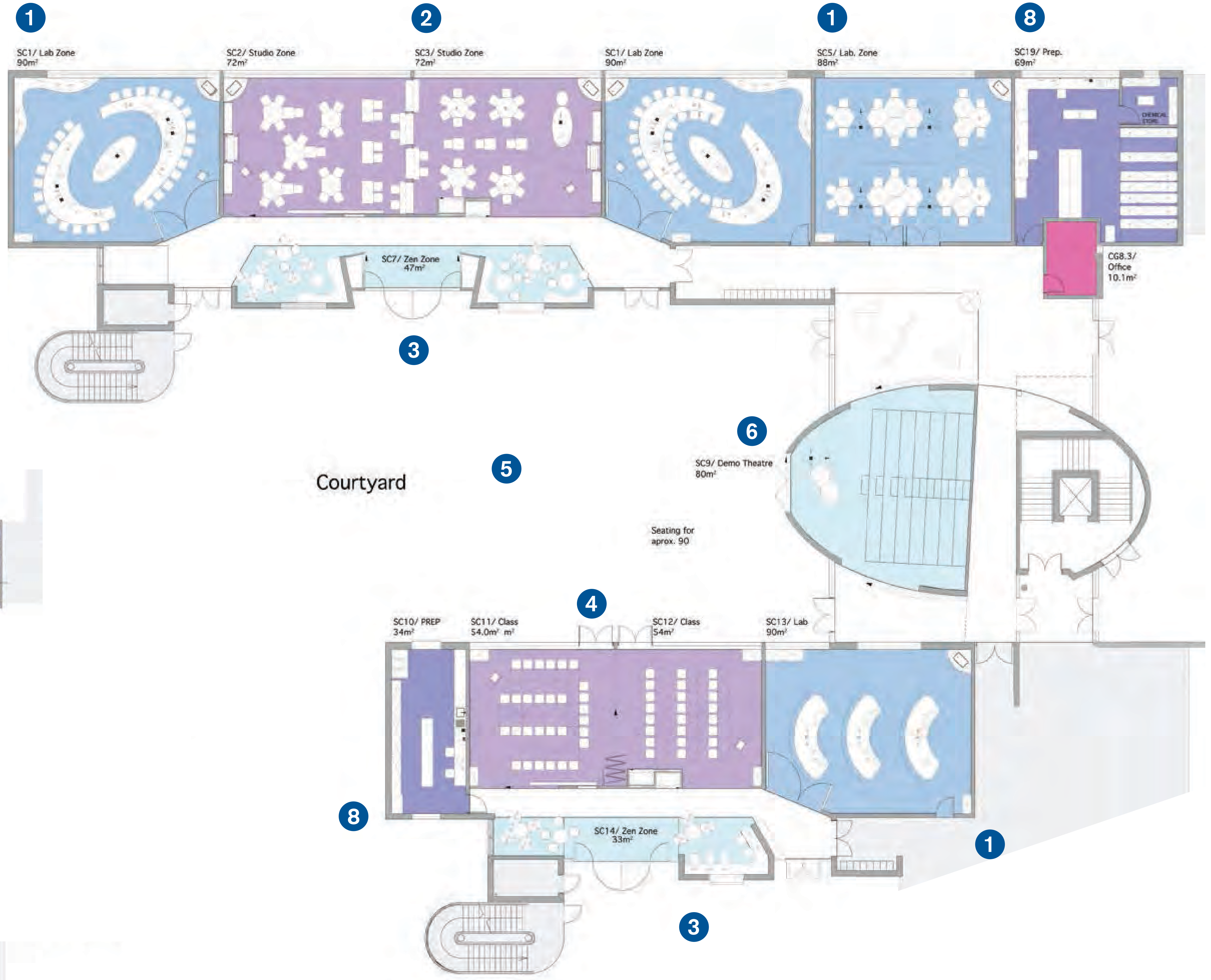
The core elements of Bideford's proposals are a demonstration/teaching theory space and 'learning commons'. The learning commons consist of two labs, two studios and two breakout spaces – zen zones. Taken together, the core elements will serve for practical and theory work, for large and small groups.



Detailed 2nd floor plan



Detailed 1st floor plan



Detailed ground floor plan

1 Eight serviced laboratories (90m²)
The labs' main function is to provide a space for students to engage in rigorous scientific investigation. Access to services like gas, electricity and water is essential. The space is designed for practical exploration and application of science.

Two crescent-shaped benches with full services allow excellent supervision and clear views from students to the teacher and to all other students.

2 Four science studios (72m²)
Used for a range of science activities, with access to a sink and water, power and data, it's not a heavily serviced space, except for one fully serviced demonstration bench. 'Light' science experiments will take place in the studios but the focus will be on analysis, presentation, discussion and debate.

The studios are in the middle of the suite of spaces and can be opened to form a continuous space, screened but not separated from the zen zones. The zen zones are located to allow an easy flow between the three types of space.

The predominantly open plan form allows the zen zones to be monitored from the studios. Moveable screens can separate spaces without sealing them acoustically. The labs at each end may be open to the common but can also be closed off from it, and the learning common provides direct access to an external science courtyard.

These two studios are connected to two screened breakout areas for small group work or individual study.

3 Four zen zones (33/47m²)
Designed as a breakout space for the adjacent studios and labs, they support individual and small group activity, with a focus on informal learning and space for quiet reading and reflection.

4 Two classrooms (54m²)
A general teaching space for learning about theoretical science. This space can be configured for a variety of approaches to learning and teaching, and may be used for theoretical science lessons as well as other subjects as part of an interdisciplinary curriculum.

5 External lab/class and ecological landscape
The courtyard provides external learning and teaching spaces. More infomation is provided over the page.

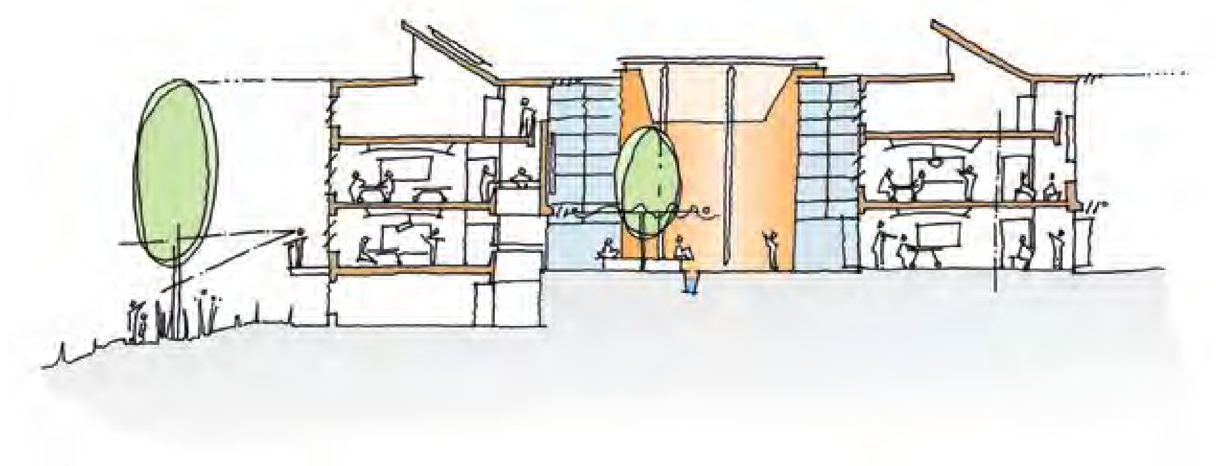
6 Demonstration theatre and teaching theory space ('PLTS', 80m²)
To be used as a common resource for the school and wider learning community, but predominantly for science. The theatre and teaching theory space are focused on demonstration and performance, for lectures and evening use, innovation and sharing best practice. Leading edge teachers can come and perform, observed by colleagues and peers. These are non-timetabled areas, with the expectation that they will be bookable or used in innovative ways to change the curriculum experience.

The areas form the heart of the science department, close to the entrance and opening out onto the science courtyard. The demonstration theatre is two storeys high, allowing the possibility of raked seating. By opening onto the teaching theory space and adjacent laboratory, large-scale experimentation will be possible.

7 Science lounge
This space on the second floor is for informal learning. It has a crescent-shaped roof terrace, overlooking the courtyard.

8 Prep rooms
There is a prep room on both floors and the first floor prep room is adjacent to the staff workroom for easy access.

9 Staff room
The staff room on the first floor has space for group and individual work. It also has a seating area outside where students and teachers can meet informally.



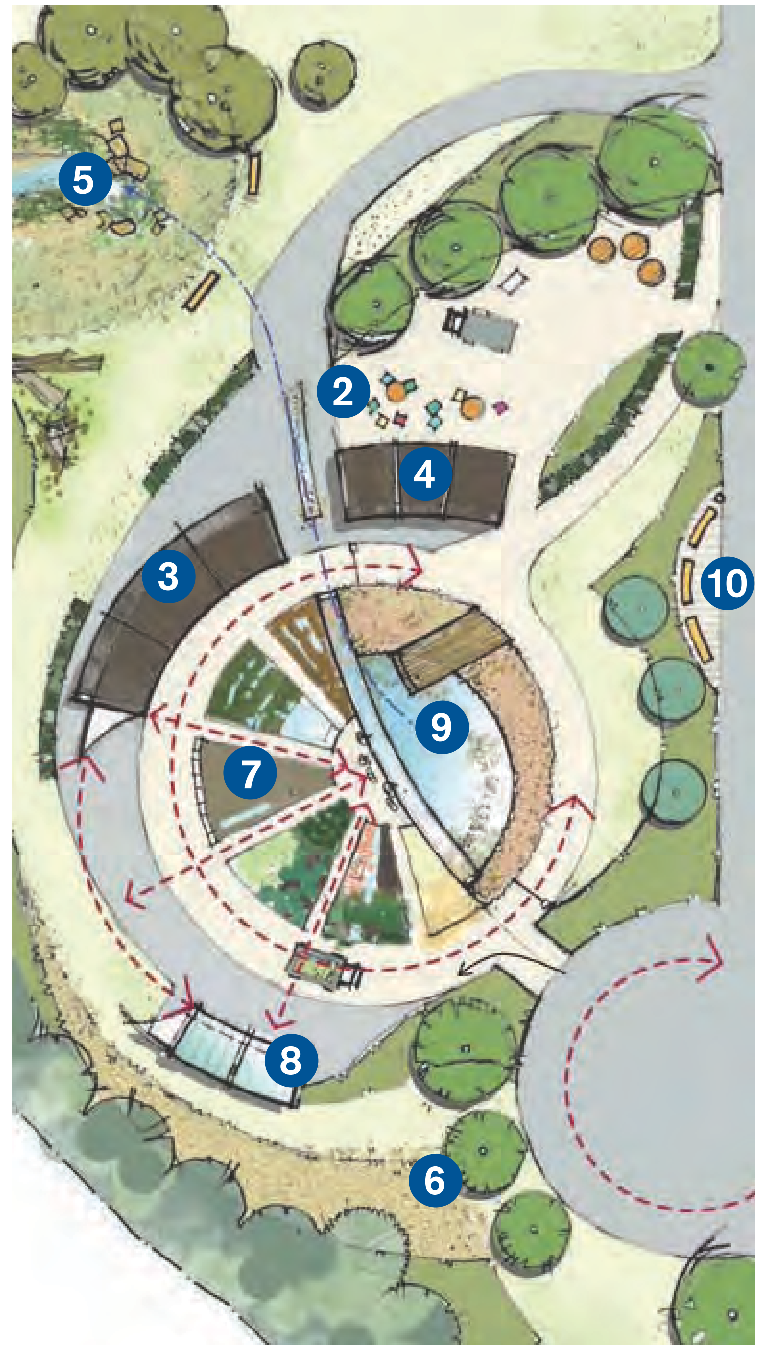
Wide, level-access doors let students get to the outdoor learning area easily.

The learning space in the courtyard will be protected from wind and rain.

The design reflects Bideford's dual status as a sustainability and science demonstration school. The two aspects overlap in many ways – a narrow plan means there's good summer ventilation, less electrical lighting is needed, and there are good views outside, with a visual connection to the grounds. The views help to emphasise the links between the school and the natural environment, and implicitly remind students of wider sustainability issues.

The department is organised around direct, easy access to an external courtyard designed as an external teaching and learning space. This will be delivered through student design when the building and site works are complete, and when funding allows. Adjacent to the science department will be an ecological landscape with food production areas, an example of a sustainable building and a demonstrable SUDS scheme (see image opposite).

The learning experiences provided by the building fabric and the grounds are enhanced by exposing elements of design – structural, materials, renewable energy generation or landscape – thus turning the facilities themselves into an educational tool.



Plan of the outdoor areas showing the sustainable technologies building, glass house and other outdoor facilities enclosing a circular zone for horticulture. It has radial divisions for different experimental conditions and an irrigation channel running through the middle.

1 Outdoor classroom, with moveable seating and tables, a yard for storage, composting and recycling

2 Sustainable drainage system (SUDS), using a filter and reed bed

3 Sustainable technologies building, built using a frame structure and pleached trees

4 Extra storage and learning space and recycling

5 Wetland habitat and SUDS

6 Wildflower grassland habitat

7 Planting beds offer a range of growing conditions: hydroponic, organic and raised beds

8 Glass house/nature hide

9 SUDS Water collection point

10 Seating cove

Cost commentary

- The main additional costs are due to additional gross internal floor area of 243m^2 associated with the demonstration theatre and science lounge. It's the school's intention that the demonstration theatre will be shared with other curriculum areas, other schools and the local community, as well as being used for teacher training events.
- There are also additional costs due to the folding acoustic partitions between laboratories, screens, enhanced services and services equipment and some non-standard fittings and furniture throughout the layout.
- The extra cost of the conceptual design (compared to a traditional science facility of 15 labs) is £330/m^2 of the gross internal floor area. This is in the middle of the cost range of the extra over costs that have been identified for the six Project Faraday schools.

CLEAPSS comments

- All rooms opening onto a glazed corridor, part of which will be used for small group learning and teaching, has the advantage that pupils waiting outside the lab or science studio at the start of a science lesson will not be crowded (which can lead to misbehaviour).
- Having two chemical stores, one on each floor, is likely to create some confusion, particularly for maintaining and checking stock. A single store for the bulk storage of chemicals would be simpler and more useable. However, a nearby lift allows materials and equipment to be moved between floors.
- The lecturer's bench in the demonstration theatre provides gas, water and electricity. These services will need to be securable, especially since the whole area of the demo theatre will be more fluid in nature, including being opened up to form a single large space. This can be organised through one or more key-locked shutoff switches, but another possibility would be to have services that fold away into the lecturer's bench, so not on permanent display. This would mean they would not impede non-science lectures or events.

Renewals case study 03

Rednock School

This school offers a true science journey from the entrance doors to the science department with an 'immersive' incident centre as a focal point.

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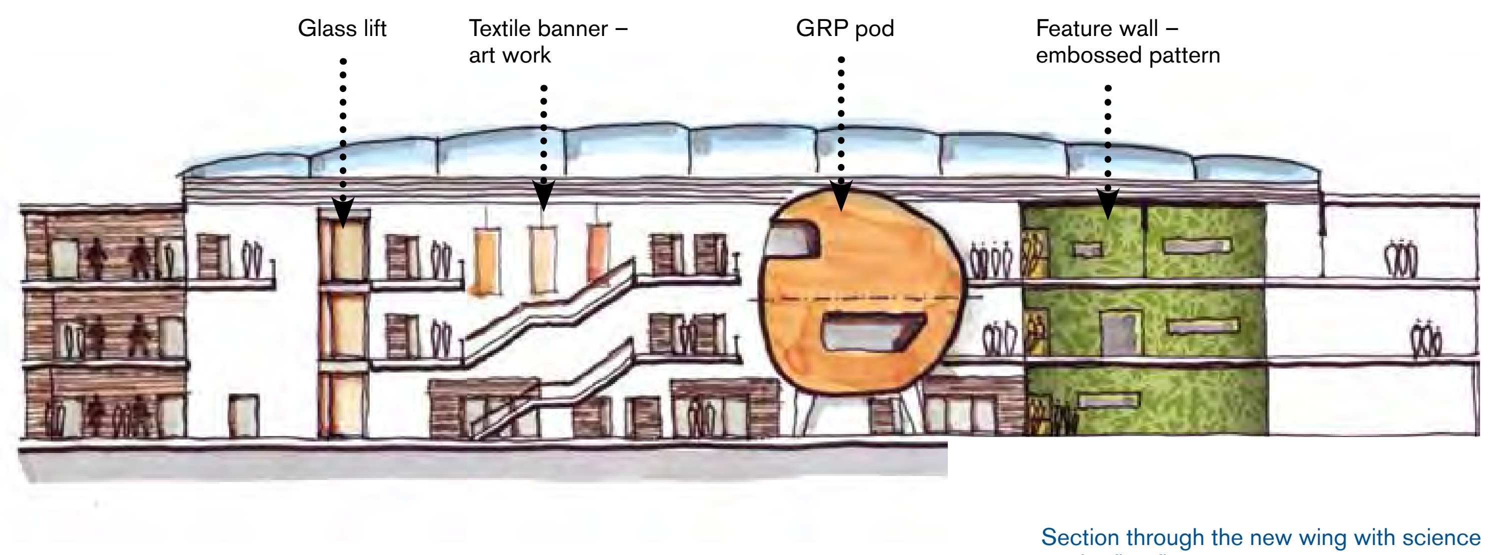
GovEd Communications
cube_design

This aerial view of the site shows science accommodation in the foreground, with a large roof light running along its spine.



Section through the new wing with science on the first floor.

Rednock School is a science specialist school with a catchment area of about 100 square miles. Apart from three or four existing buildings, Rednock will have a completely new school ready to open in September 2009.

Parents and the community view science as one of Rednock's strengths. The school itself sees science and the 'reinvention of science' as a springboard for connecting to other departments, the wider communities, primary feeder schools, and further education facilities, including Bristol University and Explore@Bristol.

The school's provision of a global dimension in all aspects of its curriculum was recognised by the British Council in 2004 and 2007, which awarded the school 'International School' status. Students are presented with many opportunities to learn about the global community, both within and beyond the classroom environment, and pursue this vital aspect of their learning with a wide range of partner schools, both in this country and abroad.

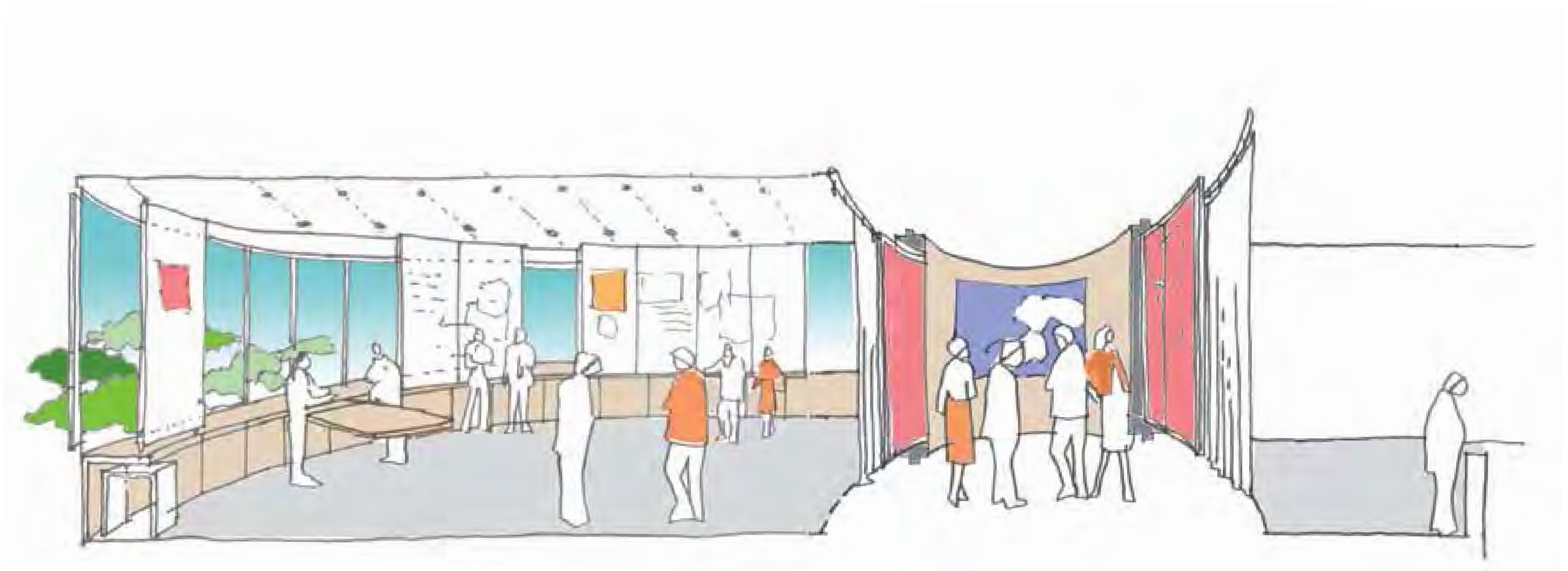
When Project Faraday started, the new school design was already at RIBA Stage D – detailed design was underway. The Faraday team developed design options for the science suite of spaces but their main input related to fit-out, furniture and internal partitions.

Science teaching is at the core of Rednock School's educational vision. The school devoted a lot of time to considering how its aspirations can be achieved in the physical form of the building and grounds.

The main principles were:

- The building should reflect the school's concept of personalised and independent learning with a skills-based curriculum crossing disciplines.
- Rednock School should be a sustainable school. This aspect of the brief was influenced by input from the students.
- There should be flexibility to use different learning and teaching methods in classrooms, and the outside environment should be accessible.
- The school has a role as an adult learning centre and the building should be a resource for the entire community – including a performance space for them – since there are few other community facilities in the area. The entrance should welcome the community.
- The science facility will have at its heart an 'incident centre' for problem solving scenarios – for example, future developments in health and disease, linked to climate variations.

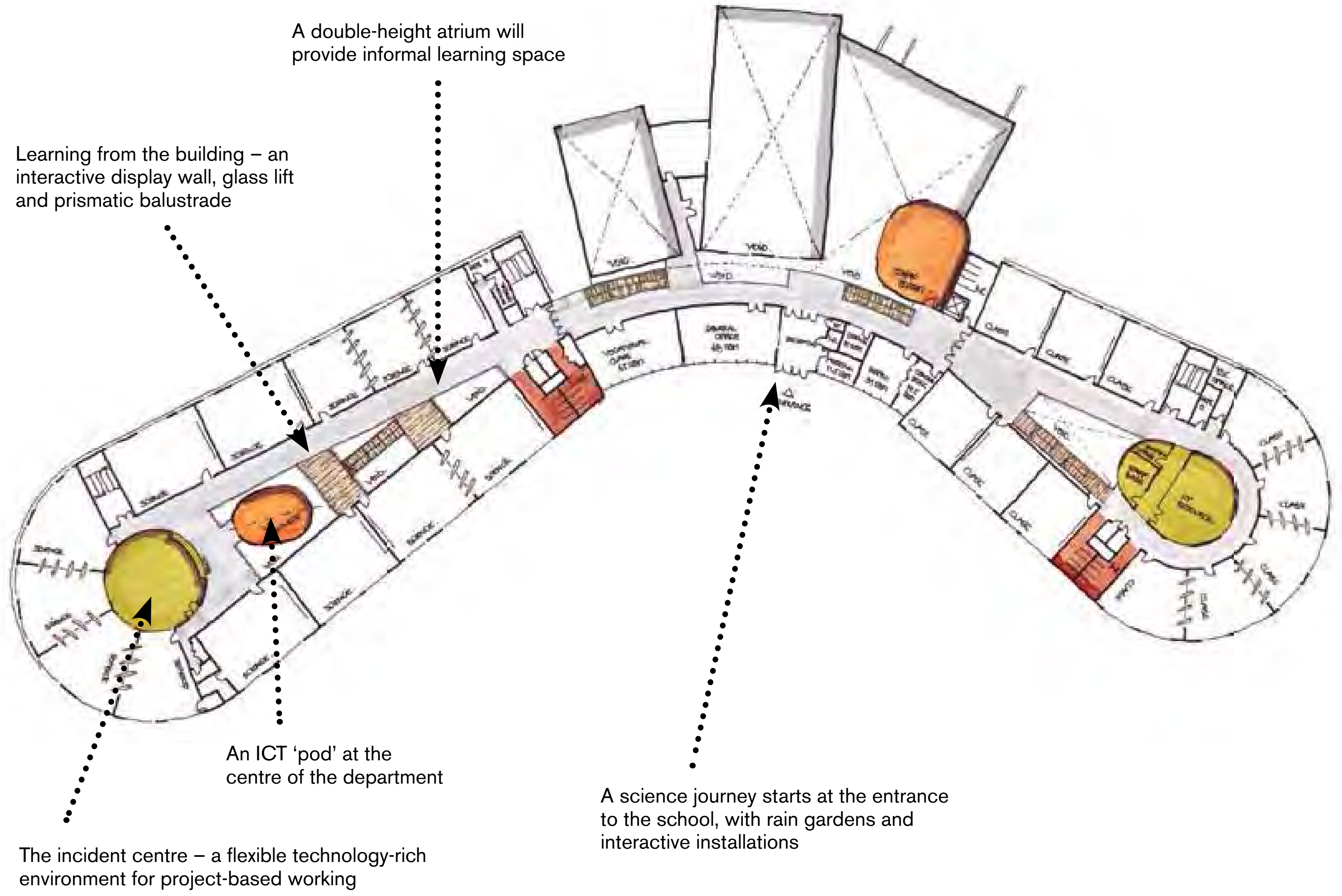
The new school facilities had to sustain and reinforce established links outside – including local universities, the BBC and schools in the UK and abroad.



This 'incident centre' at the heart of the facility will be a focal point for problem solving and role play. Moveable screens will allow it to be opened up to the adjacent teaching areas.

Science is at the heart of the school.

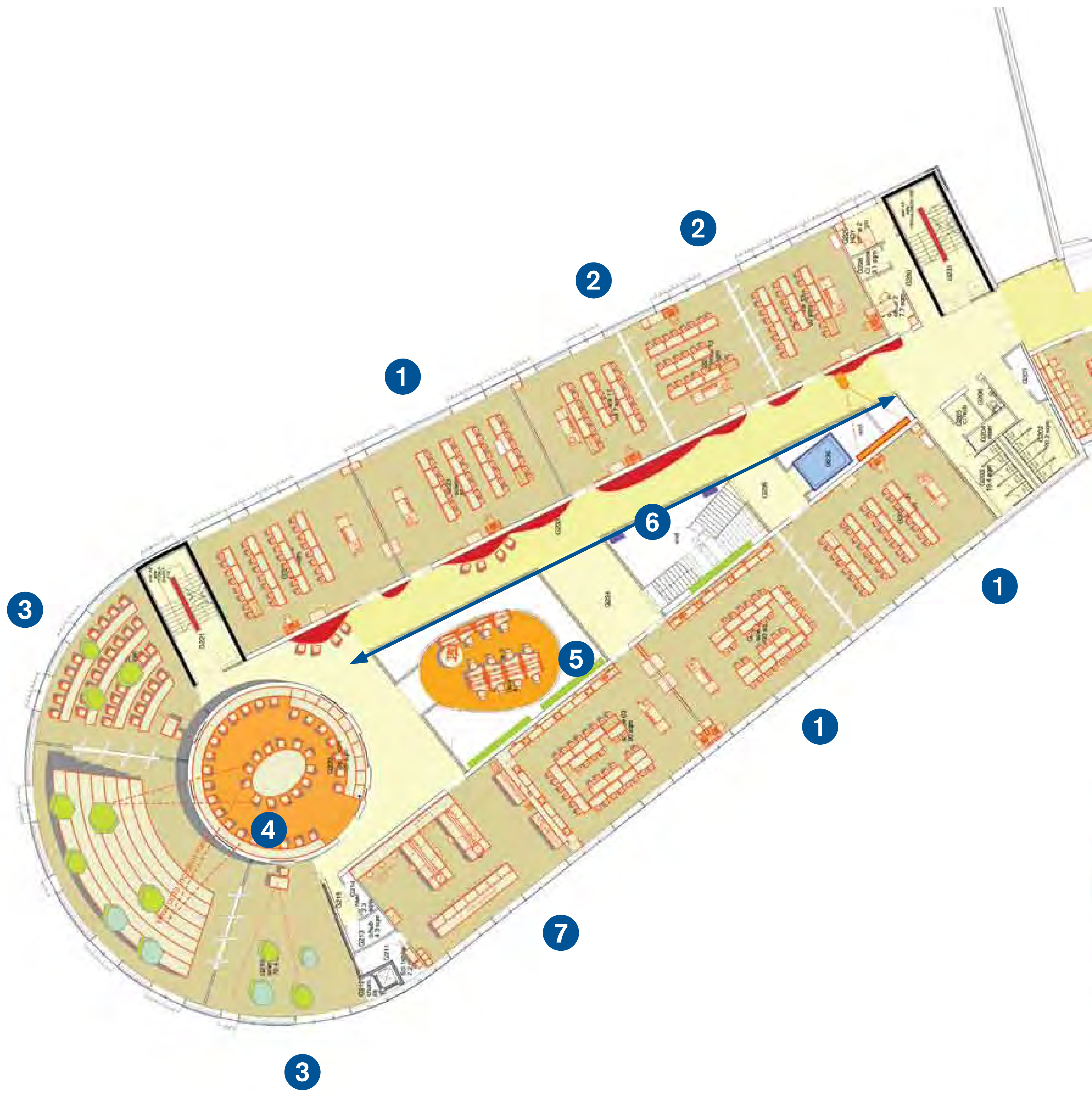
- A 'science journey' starts when you enter the school grounds, leading students into the science wing and the incident centre, where they are exposed to real-life science dilemmas and work together to reach solutions to them. The idea is that all parts of the school buildings and grounds can be used as tools for teaching, adding to the learning experience.
- ICT and learning make use of the building and grounds for data collection, particularly as many new technologies are mobile and allow students and teachers to 'roam'. There's a particular emphasis on studying the building and grounds as they change through the seasons.
- The designers focused on meeting two key elements of the brief – personalised learning (which meant providing spaces that would support students in taking responsibility for their own learning), and flexibility (which meant the design team had to think hard about furniture layouts and the sort of furniture they specified for science areas).
- Rednock aspires to using digital technologies creatively for science. The design supports this by providing structures to allow for great flexibility of teaching, and to slot in new technologies as they become available.
- The project team aimed for 'loose-fit' integration of digital technologies, so that the fit-out of the building can be changed over the short or long term to support the technology. A flexible, or at least reusable, approach to buildings will help extend the life span of the building and therefore improve its sustainability.
- The school specifically wanted a central atrium (a glass-roofed internal area) for learning as well as circulation. It's not intended only for science learning, but also for maths, geography and other subjects. The atrium will also be used as a 'spill-out' space for less formal teaching, particularly in science. The students will circulate via the atrium and will always be aware of its 'interactive wall' showing student science work.



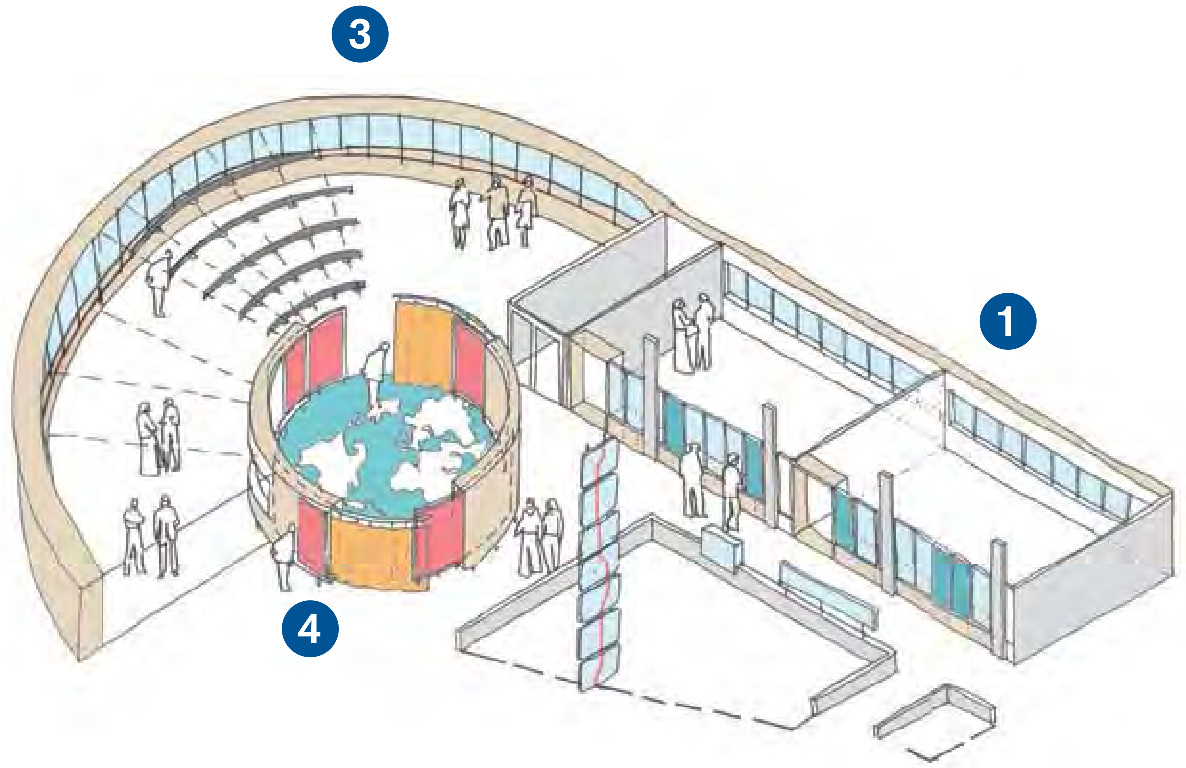
Concept plan showing key features of the design

The science spaces are arranged around a top-lit atrium. There are varying levels of sophistication in terms of services for rooms, and rooms are different sizes according to their function. The whole area is wired for ICT and screens. The approach is to create an environment in which students will lose the sense that they are at school.

Rednock School's proposals consist of six fully serviced labs, two smaller dry labs and three multi-purpose rooms with sliding partitions. There is also an incident centre – perfect for strategic thinking and problem solving.



Detailed floor plan



One of the preliminary sketches for the incident centre

1 Six serviced laboratories (90m²)
A flexible layout, with fixed, fully serviced practical workspaces along the sides of the room, supplemented by mobile practical stations with additional power and data. All teaching spaces have moveable and flexible services, to give maximum potential for adaptation.

2 Three multi-purpose rooms (60m²)
Two sliding walls between them, with acoustic insulation, mean they can be opened for large groups – particularly useful during the school's science festivals and for large group presentations.

3 Two dry labs (70m²)
Intermediate practical work spaces between fully serviced labs and the multi-purpose rooms, not equipped for wet practical work. They will have moveable power and walls and moveable, modular furniture.

4 Incident centre
The dry labs, the auditorium and another larger space will be interconnected, divided by sliding partitions, and linked to a central hub that will form an incident centre, a space for students to carry out decision making, strategic thinking and problem solving – cast as government officials, for example, reacting to an event or situation, such as the Gloucestershire floods.

Budgets permitting, the incident centre will be fitted out as a stage set, with layer upon layer of flexible enclosures and technologies that the school can use in different ways as its learning and teaching evolves. Sliding screens or full height curtains allow enclosures to be defined in more or less formal ways. If funds allow, this incident centre will create different environmental conditions using lighting, plasma screens, ICT and theatrical visual reality elements on the surrounding walls and enclosures. This caters perfectly to the school's plans to maximise cross-disciplinary learning and teaching.

The stage sets will also be able to create and simulate virtual reality spaces, using three-dimensional stereo projection – already used by the military and for entertainment. This can be as simple as having two overhead projectors, set at 90 degrees to each other. For a modest cost, it offers a wide field of view and greater realism for students. It also allows multiple users, and for viewers to move in 3D.

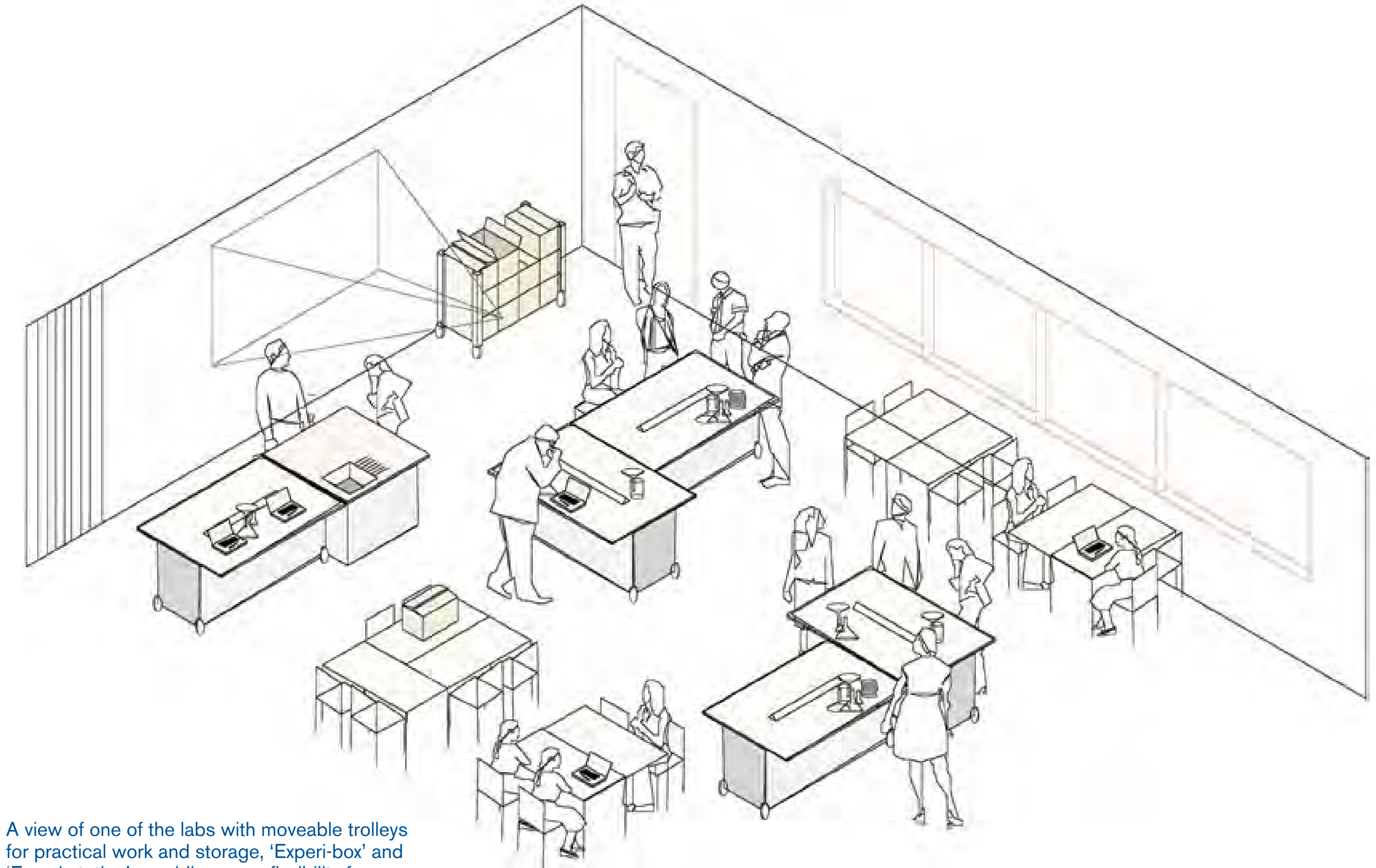
Recessed lockers will be hidden in one of the walls of the incident centre to provide extra storage space.

5 ICT pod
In the atrium near the centre of the science department, the ICT pod will have 12 workstations for students to carry out research on the internet and for other computer-based learning.

6 Learning wall
One of the walls in the atrium will have a series of informal breakout areas, where small groups of students or individuals can work away from the distractions of a larger group. There will also be a large measuring scale on the ceiling. Like the glass lift, rainforest images and a dinosaur fossil elsewhere, this helps to make the building itself useful for science learning.

7 Prep room
A central prep room serving the whole department and well positioned to support the incident centre.

This artist's impression gives a flavour of what the finished science wing will look like.



A view of one of the labs with moveable trolleys for practical work and storage, 'Experi-box' and 'Experi-station', providing more flexibility for science learning.

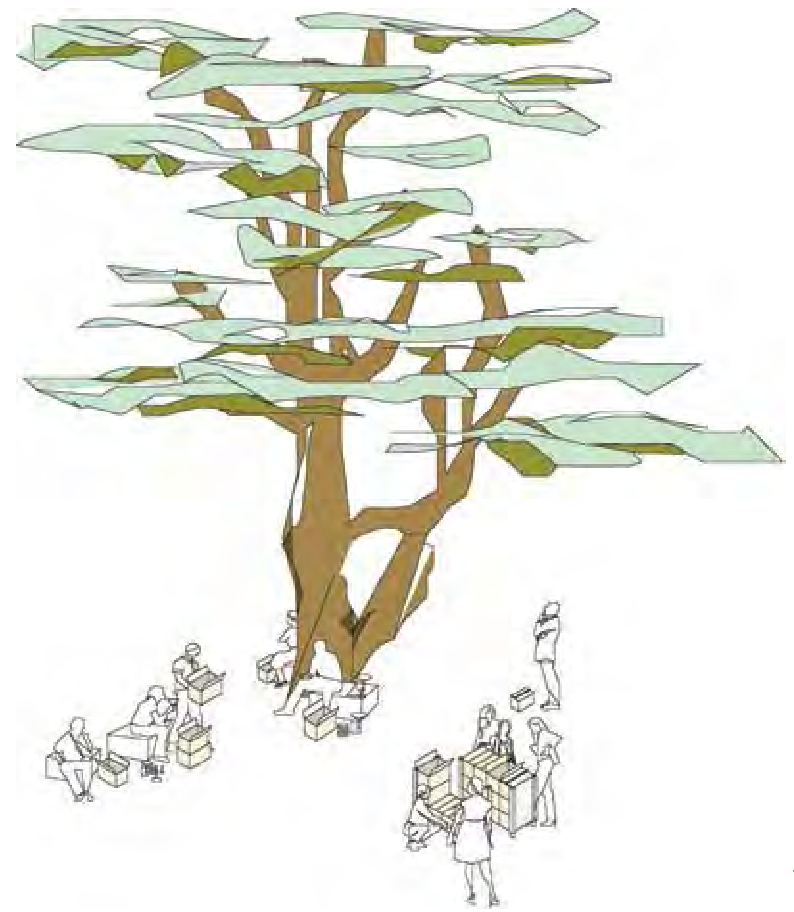
The school plans to use a number of building features to demonstrate scientific concepts including a prismatic balustrade. As well as being a beautiful object and a design feature, the balustrade will help teaching about the way light behaves, showing how different wavelengths of light refract and reflect differently in a prism.

Pupils will learn from the school's sustainability measures. The school was assessed as 'excellent' under BREEAM (the Building Research Establishment's Environmental Assessment Method), and is aiming for carbon neutrality. Sustainability measures include a 15m-high wind turbine, underfloor heating linked to a biomass boiler fuelled by wood pellets, photovoltaic panels (generating solar electricity) on the roof of the main hall, and a sedum roof. The biomass boiler alone is estimated to save 160 tonnes of CO_2 each year.

Rainwater will be collected from the school's roof for flushing toilets, which will reduce the mains water use by around 750,000 litres a year. A SUDS scheme will deal with the remaining rainwater, using swales, permeable paving and a wetland study area.

There are outdoor teaching spaces, with active educational installations tied into the curriculum. For example, there's a weather monitoring station and the rainwater harvesting system can be used in science teaching, both for climate topics and fluid dynamics. Outdoor areas are planted with indigenous plant species, and one of the two existing mature cedar trees is equipped with a growth monitor for long-term experiments.

The Faraday team considered furniture for the school very carefully, and came up with a series of innovative ideas, from an 'Experi-box mobile trolley' to an 'Experi-station'. The first is a robust trolley with a series of built-in storage boxes, completely independent and suitable for fieldwork and students working in groups. The second, which supports practical work indoors and possibly outside, has a small amount of storage space and incorporates small power and data services. It's suitable for cross-curricular work – for example, transforming a sports hall into a venue for sports science investigations.



Moveable trolleys will allow students to work outside.

"We want to see what happens for real, not reading it from a text book."•

Cost commentary

- The concept designs for Rednock School extend beyond the core science accommodation, enhancing the science learning journey from the entrance to the science department. The cost of these items is in addition to the costs stated below.
- The main extra costs relate to the incident centre (feature ceilings and moveable service pods to the lab, projection equipment and plasma screens), interactive display walls, and the scenic lift. In addition there is a GRP pod that is within the science department, although this is part of the overall school design and not particular to Project Faraday.
- The extra cost of the concept design compared to a traditional science facility of 13 labs is £583/m² of the gross internal floor area. This is at the higher end of the cost range of the extra costs identified for the Faraday schools.
- The school is planning to phase in the most sophisticated technology as their budget allows

CLEAPSS comments

- The demountable walls between labs and around the 'hub' offer many interesting possibilities but must provide adequate sound insulation when closed.
- The design, structure and material used for the partitions must be carefully considered to avoid a fire hazard, particularly where they combine with a run of fixed benches to form the dividing wall between labs.
- Access to perimeter benches should not be hindered by loose furniture when the benches are required for whole class practical work.

Renewals case study 04

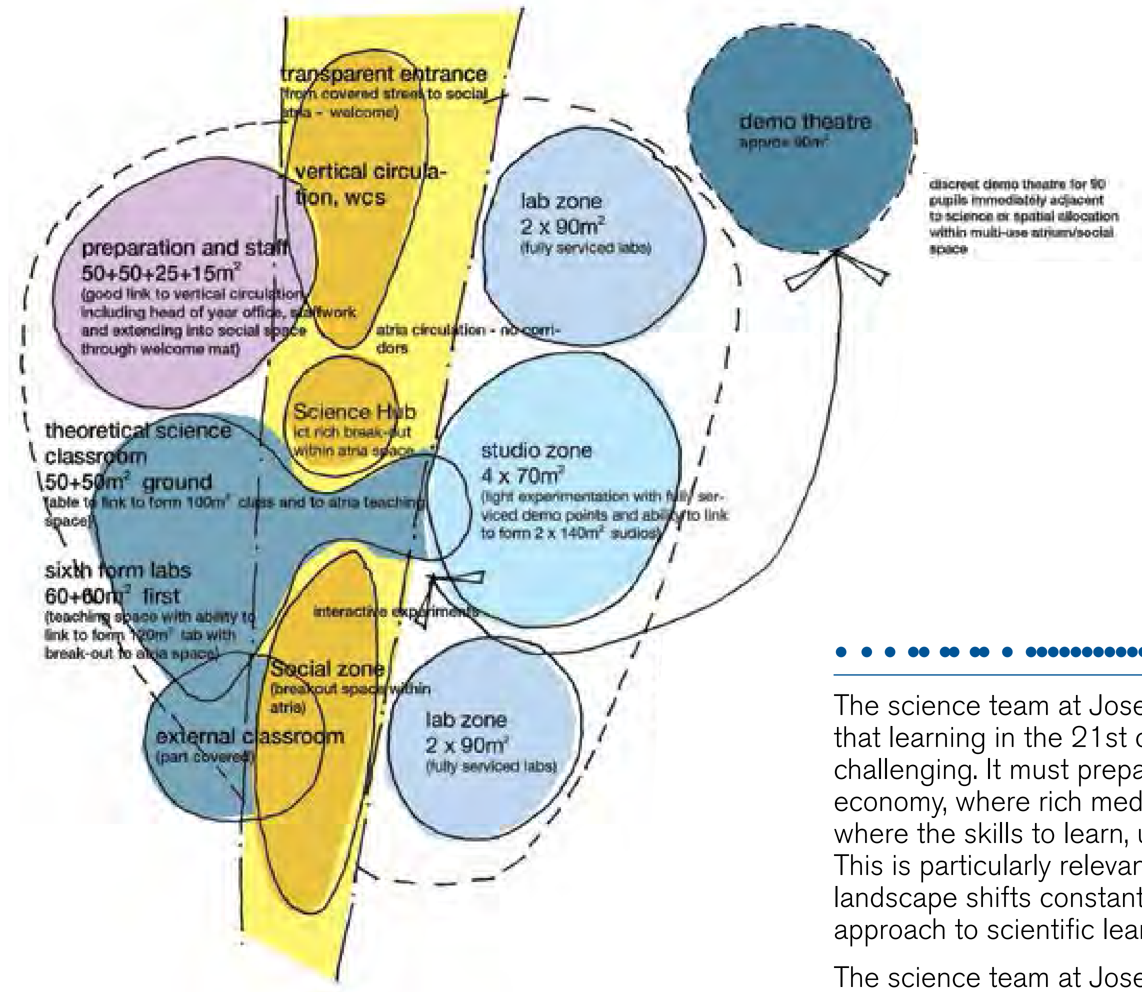
Joseph Rowntree School

A school with a suite of spaces around a central hub, designed for transformation over time and a cross-curricular approach to outdoor spaces.

1320
City of York Council
11-18

White Design Associates
DSP

An early site plan shows the school's new buildings in colour arranged along a top-lit street. Science facilities are in a two-storey building in the north-west corner.



The Joseph Rowntree School in York was assigned technology college status in 1998. All students spend one third of their time studying specialist subjects – ICT, science and design technology and mathematics. All study science up to 16, and more than 80 per cent do double science. The school is committed to students taking responsibility in their own learning.

Each student is given a target in Key Stage 3 (age 11-14) and a level ladder with tips on how to move up it. Students are rewarded for meeting and beating these targets.

When Project Faraday started, Joseph Rowntree School was developing concept design ideas for its science facilities and were at RIBA Stage B.

The science team at Joseph Rowntree School recognises that learning in the 21st century has to be fast, dynamic and challenging. It must prepare young people for a knowledge economy, where rich media resources are normal, and where the skills to learn, unlearn and relearn are essential. This is particularly relevant in science, where the scientific landscape shifts constantly and a proactive and creative approach to scientific learning is crucial.

The science team at Joseph Rowntree School defined a set of core beliefs about learning that are at the heart of their vision for science education. These beliefs have major implications for the team's vision for science learning in the 21st century:

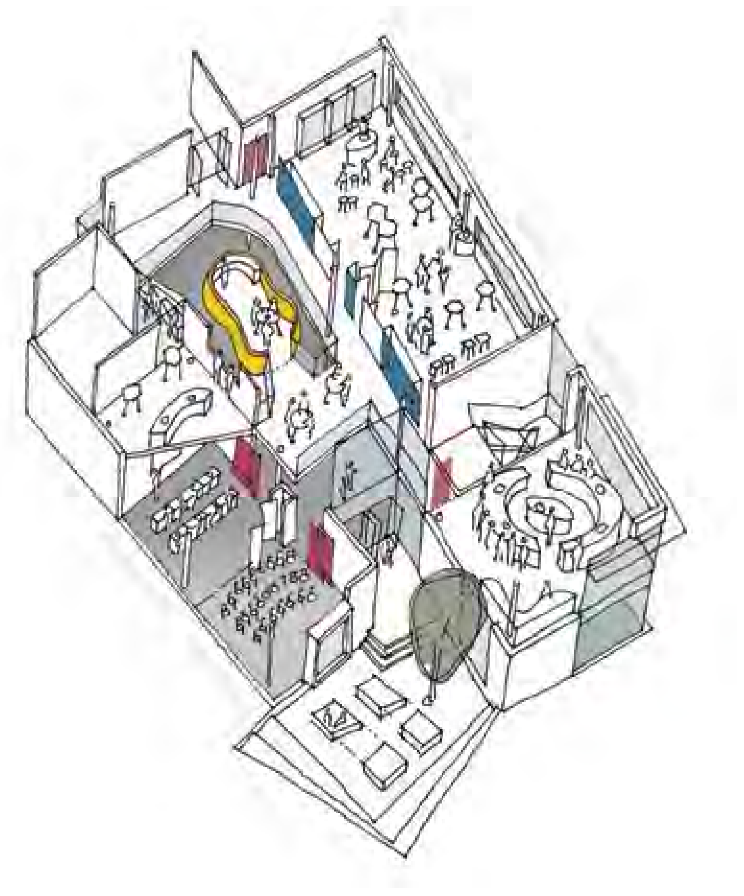
- Less focus on content – giving the opportunity to be more creative with the curriculum
- Greater focus on skills for learning and scientific literacy – so students can have experiences that develop a range of skills, and discuss, debate and work collaboratively
- An emphasis on how science works – doing more practical work, reflecting how students prefer to learn science
- Greater student responsibility for learning – applying research-based approaches to science
- More collaborative work – since many students learn most from their peers
- ICT that's fast and ubiquitous – supporting the needs of discerning users who use technology to meet specific learning needs

The science team has a vision of the future where the main impetus is its role in facilitating and leading learning, working alongside young people to empower them to own their learning. The overarching vision for science education is one that extends beyond laboratories and embraces a range of spaces which encourage curiosity and exploration and enable collaborative approaches to learning. This new science learning landscape extends across the entire school campus, exploiting the links between the internal and external.

The Faraday team worked with the school's design adviser and, although they focused on the science facilities, there was also some input into the whole school design. The Faraday artists, educationalists and architects ran four one-day workshops with staff and students. The school's vision encapsulated the designers' three central requirements:

- Distinct teaching departments grouped around a collective school 'heart'
- Flexible links across a central atrium space
- A clear relationship between the school and the external environment, in the form of a sheltered and partially covered space

To support the educational vision for science, and following a review of recently built science accommodation at other schools, the team agreed that learners should have access to a range of spaces of differing sizes. The following essential spaces and facilities were identified:



There's a mixture of fully-serviced labs, lightly serviced science studios and simpler classrooms. The atrium includes informal teaching space and an ICT hub.

Practical spaces
Students and staff need serviced laboratories, suitable for a range of practical investigation activities. They also need access to lightly serviced wet practical space, giving greater flexibility for organising science learning, so groups of up to 60 students could learn with a team of supporting adults.

Spaces for collaboration
Breakout spaces for small groups and pairs to work together are built into the design proposals. The space must also enable students to move efficiently between practical and collaboration spaces, and to work across the boundaries between disciplines.

Spaces for performance
Here, students can celebrate their achievement and present their learning to peers and others. The space will build capacity for working in new ways – it must enable three classes to group together, and be reconfigurable so the flat floor space can be used too. It's also planned that staff will lead lectures here. Other departments will use it in similar ways.

Preparation space
Centralised space, potentially with two or three distinct zones. The science team wanted the preparation space located next to staff work spaces to encourage collaboration.

Sustainability
The design enhances learning experiences by exposing elements of the building fabric – structural features, building materials, renewable energy generation and landscape features – so the facilities themselves become a supplementary educational tool.

Owned areas
It's important to have spaces that students and staff can identify as their own, especially for staff interaction, the celebration of student work and more informal learning and social interaction.

Circulation
Safe routes between practical spaces are essential, so materials can be moved safely from one room to another. But circulation through the science accommodation should be kept to the minimum, ensuring maximum space available for learning and teaching.

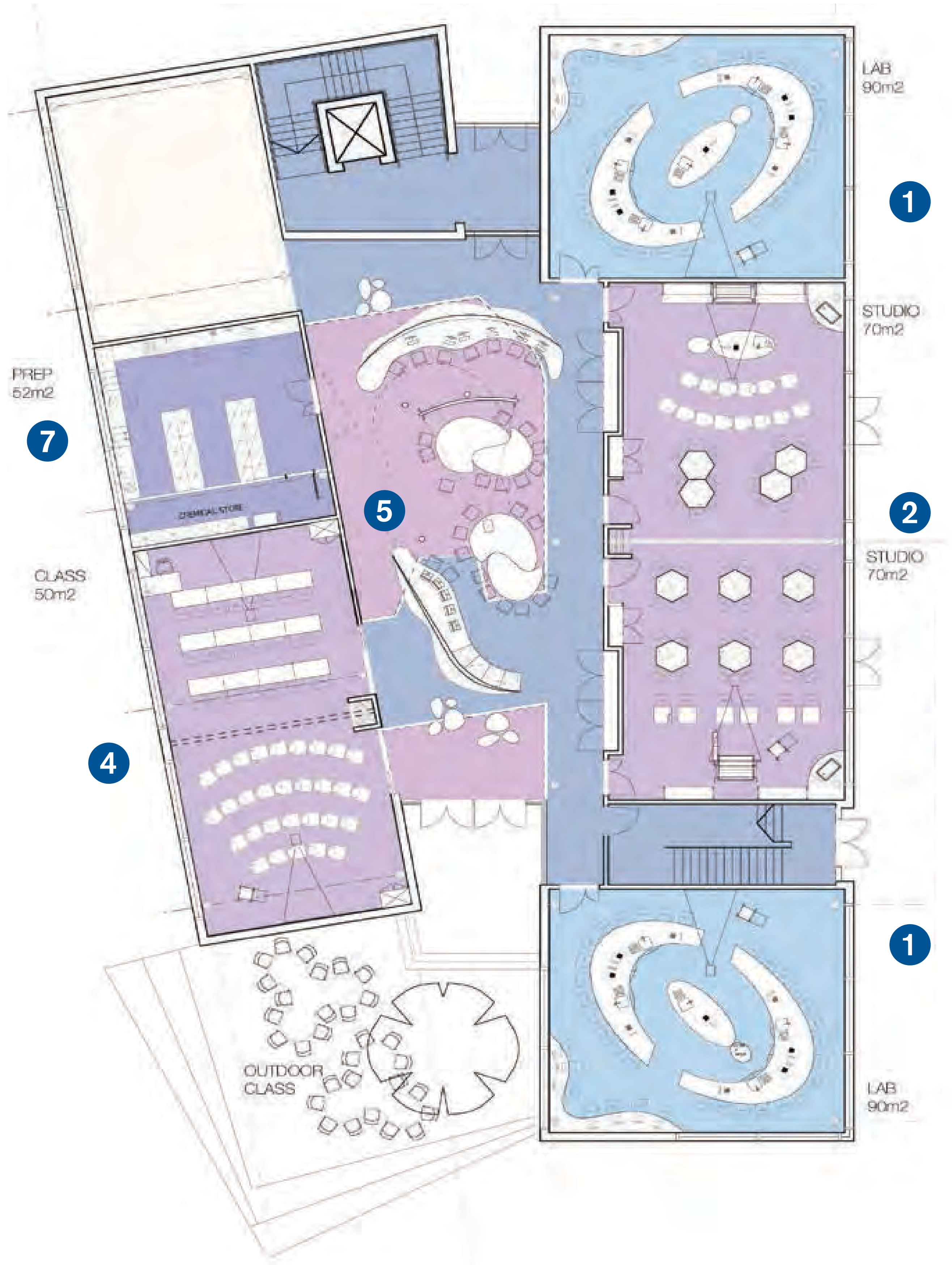
Light, acoustics and internal environment
Open plan spaces must have acoustics appropriate for focused group work in larger areas. Natural light and natural ventilation are important. Lighting levels must be adjustable for digital projection technologies. Designers explored the use of colour in science facilities, in terms of impact on student attitudes, from a scientific perspective and for educational uses.

Concept plan showing key features of the design

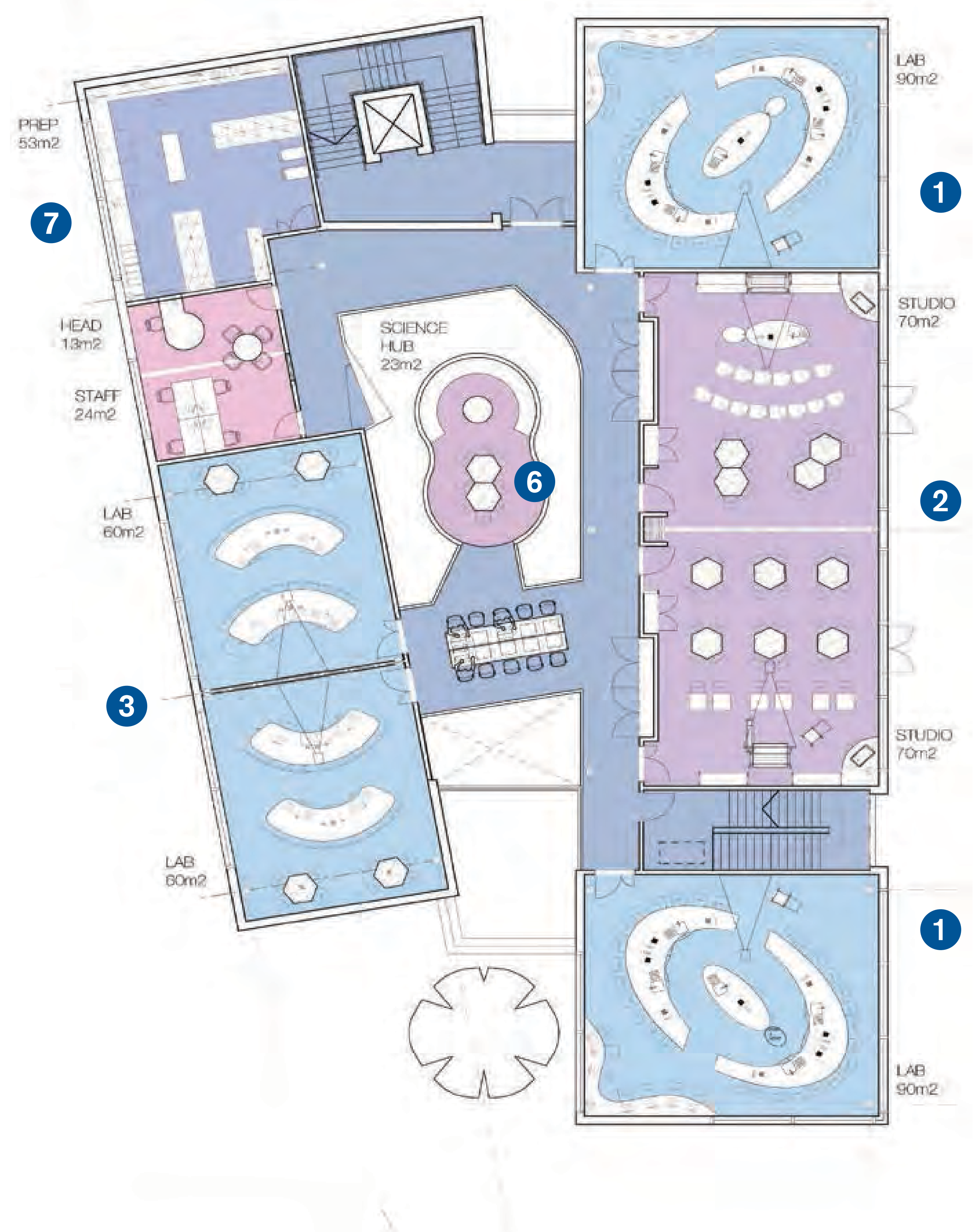
Students enter Joseph Rowntree's science accommodation from the main school at one end of a top-lit atrium, next to the main staircase. The opposite end of the atrium extends visually into the landscape by way of a highly glazed wall, specimen tree and external classroom. The design extends over two floors and includes general labs, lightly serviced 'studios', smaller specialist labs, and classrooms for theoretical work.

Each space is entered directly from the atrium, which can itself be used for exhibitions and demonstrations. This arrangement means there are no corridors. This saving, along with space savings from providing alternatives to traditional $90m^2$ labs, means that there is extra open plan learning space and a social area in the atrium.

Joseph Rowntree's design proposals include four fully-serviced labs, four smaller 'studios' with less intensive services, two specialist labs that can be combined by opening a moveable partition, and two unserviced classrooms for theory work. There is also space for informal learning in breakout areas in the atrium.



Detailed ground floor plan



Detailed 1st floor plan

1 Four fully serviced general laboratories (90m²)•
The labs and studio labs are to be located over two storeys to one side of the central atrium, forming a 'practical zone'. The studios will be next to the atrium and the laboratories remote from it to maximise possible linkages to the atrium.

2 Four lightly serviced studios (70m²)
Studios provide space for some practical work and are adjacent to the atrium so that in future, if the school wishes, there will be the option of linking them with the atrium. This would turn the space into a 'learning common' like at Bideford College. Storage space is built into the wall between the studios and the atrium, with one part accessed from either side. These storage walls are free of services

3 Two specialised labs (60m²)
The two smaller specialist labs on the first floor can be used individually for sixth form teaching, or combined together to accommodate one Key Stage 3 or 4 group.

4 Two classrooms (50m²)
These classrooms have no specialist science services, and are intended for theory work. Different furniture layouts and settings are possible, to meet different learning objectives. Initially there will be sliding partitions between these classrooms and the atrium, which means the school can move towards a more fluid, open plan model in the future without forcing teachers to jettison more conventional methods in one go.

5 Breakout space, open plan teaching space and social space
A breakout space is intended for informal, small group work and peer discussion. Space savings on the other elements, combined with a circulation allowance within the atrium, allow extra open plan teaching space and a social area.

The atrium is a flexible space that can be used for a range of activities including theory and demonstration.

6 An ICT hub in the atrium
The ICT-rich 'science hub', a free-standing element in the atrium, is for use as a breakout space from practical areas on the first floor.

Relaxed seating on the first floor in the atrium will provide the opportunity for informal and social learning.

7 Two preparation spaces (50m²)
There is a prep room on each floor, next to the department entrance with the one on the first floor linked to the staff workroom. This makes it easier for technical and teaching staff to collaborate closely.

The school is also looking into an additional space allocation of 90m² to provide a demonstration theatre, which would also be shared with other departments. This could either be a discrete space adjacent to the science department and used by the whole school or it could be an enclosed space within the department atrium.

Cost commentary

- The main additional costs are due to folding acoustic partitions between labs, enhanced services and services equipment. There are many non-standard fittings and furniture throughout, but there is very efficient use of circulation areas.
- The extra cost of the conceptual design, compared to a traditional science facility of 12 labs is £193/m² of the gross internal floor area. This is at the lower end of the cost range of the extra costs that have been identified for the six Project Faraday schools.

CLEAPSS comments

- Mains services to the labs run around the outside walls of the building for greater flexibility if internal walls need to be rearranged later. This may mean some constraints on the distribution of mains services within the room for practical work but it's not difficult to provide a perfectly acceptable room layout.
- At 70m² the science studios are not large enough for the full range of class practical work with classes of 30 pupils. The practical work possible will depend on the furniture and its layout.

Renewals case study 05

Estover Community College

Science facilities are wrapped around a courtyard providing continuity between indoor spaces and a range of outdoor settings.

1200

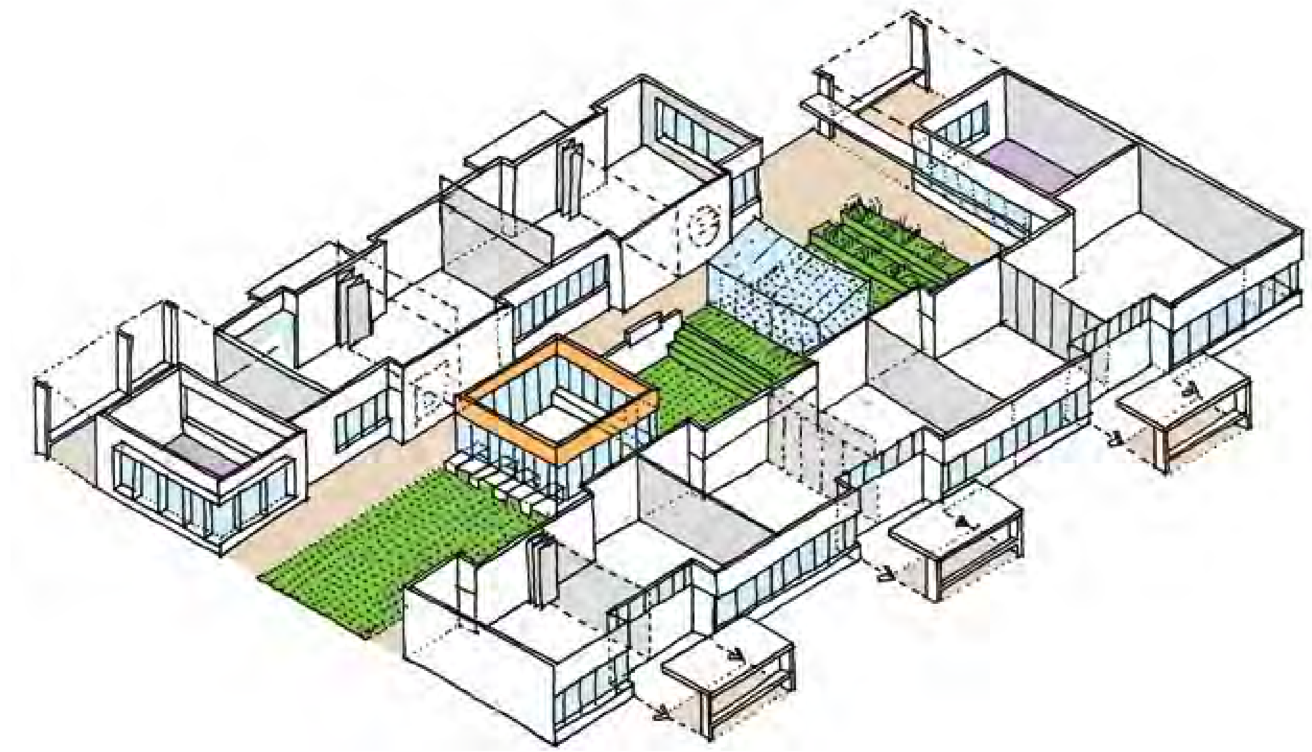
Plymouth City Council

11-19 adult community programme

GovEd Communications

Fielden Clegg Bradley Studios (Bath)

Estover's science facilities comprise two wings with a courtyard between them for outdoor learning. This is a view of a science lab.



All labs and classrooms have access to a central courtyard and small breakout space they share with the room next door.

Estover Community College is a specialist visual arts college open until 10pm and provides community sports and youth facilities. It works closely with the Tamar Science Park and Plymouth City Council and sees itself as the spiritual heart of its community.

Plymouth is an international centre for ecology and environmental sciences. The school intends to work with the Marine Biological Association and the National Marine Aquarium, capitalising on Plymouth's location on the coast and reinforcing the links between school science and the real world.

Estover also plans to collaborate with a local organic farm in teaching about the science of food production.

The site encompasses large open areas that include established rights of way and long lengths of Devon hedge. The hedges present the school with both challenges and opportunities – currently, they're a security risk because they provide cover both for mischievous students and undesirable outsiders.

Estover's vision is to radically restructure science teaching, curriculum design, and assessment, to inspire students to become creative learners and love their subjects.

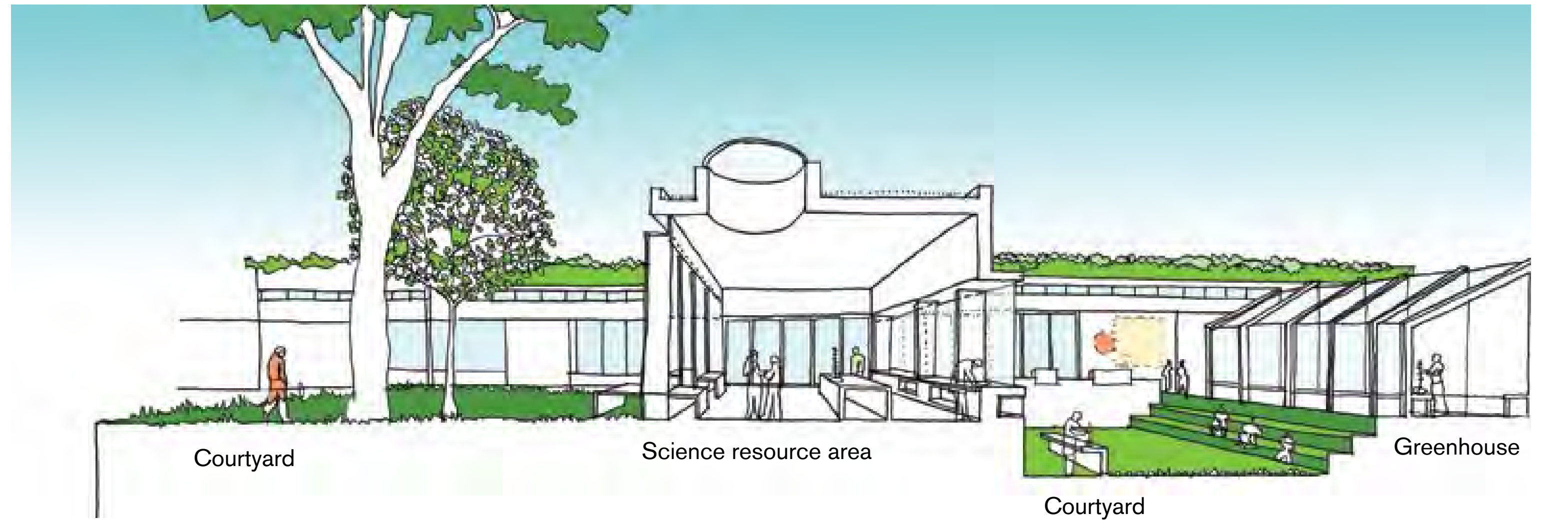
The school's philosophy of science learning and teaching is based on problem solving, experiential learning and skills acquisition, partly because staff identify content-driven science teaching as a major cause of student dissatisfaction with science lessons.

Estover's objective is to reclaim the wonder of science and return to the view of science as exploring the unknown. As part of this work, the school expects spaces for science teaching to be "enormously transformed to accommodate project-based and personalised learning".

The five main strands of Estover's vision were:

- Scientists not science students – emphasising curriculum change and a new form of teaching geared towards equipping the students with the skills and knowledge to carry out real science
- Building bridges beyond the school – generating a link between science and the business community, and with Plymouth University, to build a sense of entrepreneurship and to show how science is used outside the school
- The living building – using the fabric of the school building as a teaching resource
- Living with science – helping students to understand the impact science has on their lives
- Re-thinking lab design – to build a science learning resource centre

The school's brief to designers also included the aspiration for a rating of at least 'very good' and preferably 'excellent' under the Building Research Establishment Environmental Assessment Method (BREEAM).



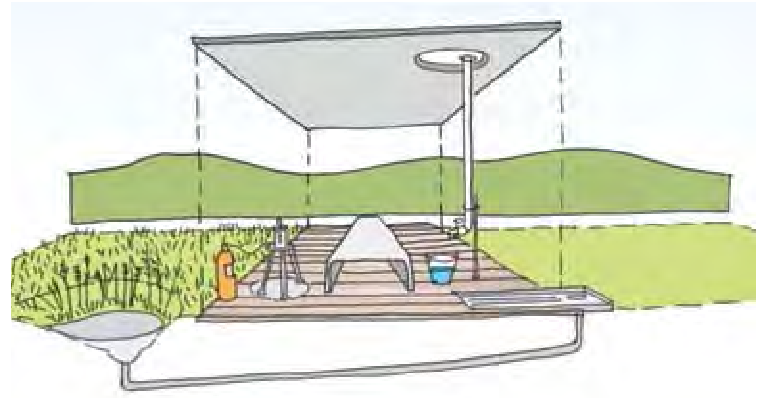
Single storey buildings and green roofs mean that the new buildings sit comfortably in the landscape. The enclosed courtyard can be used for outdoor demonstrations.

The approach focused above all on Estover's learning and teaching aspirations. Design followed this lead, so that layout and rooms were specifically developed to meet the school's plans for teaching. The science department planned significant teaching changes but wanted the transition to be gradual rather than revolutionary. (Science departments are rarely in a position to adopt wholly new practices in a single step.)

- It became clear over time that supporting the science department's short-term aspirations would have been inadequate in the long run. The solution was to formulate a design that would support the stepping stone as well as the final destination in terms of how science will be taught.
- The school's vision for science signals a move away from a single learning and teaching approach, where one environment fits all situations. So the design provides a range of different learning environments to support a diverse range of activities.
- Scale emerged as an important issue during briefing, linking the scale of learning or activity to the scale of a space. The project team worked up a generic 'family' of spaces, offering a variety of places to investigate, gather data, learn, hypothesise and explore, allowing places for individual study, public and semi-public areas.
- Connections between the lab and the world beyond came out as an important theme, both in the new curriculum and the priorities of Estover teachers and learners. Again, this is taken up in the school's design proposals, with ICT considered in detail in terms of its role in defining and improving learning spaces.

Taken together, the physical and ICT links between the school and wider community will establish it as a place of collective endeavour – as if the school and its science department is a small village linked to the larger community of Estover town.

Extensive consultation at Estover saw the science department working together as a whole. Consultation at the departmental level proved be more effective than the more common approach of consultation with individual teachers and senior staff and was particularly valuable in allowing the designers to understand and address design considerations such as the ownership of spaces.

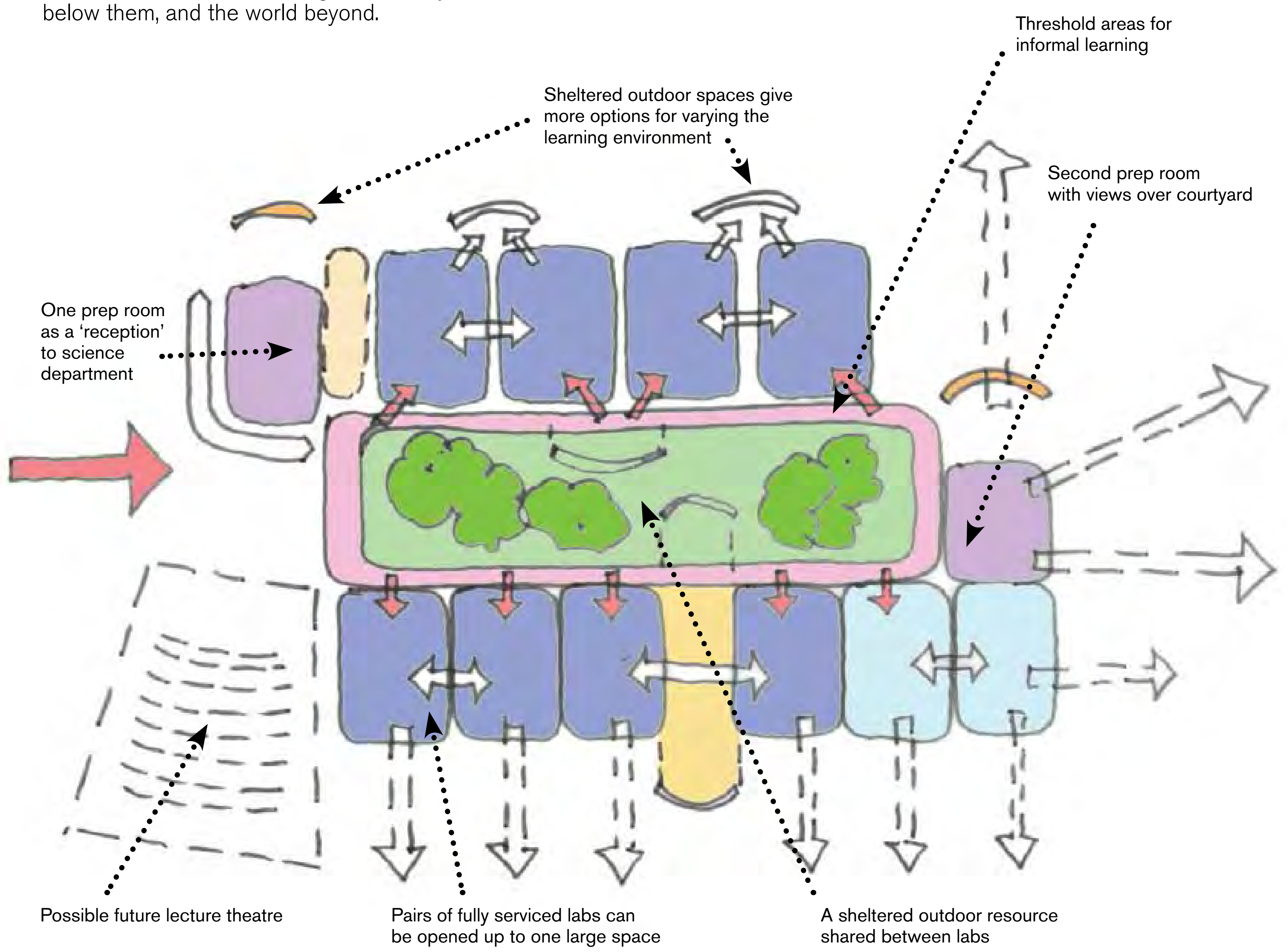


The science spaces are grouped around a courtyard with a conspicuous prep room marking a clear entrance or threshold for the department. There are 12 indoor spaces and seven outdoor spaces in total.

The facility provides a range of settings. At one end of the spectrum are informal, small-scale window seats and seating. Next come 'in between spaces' for learning and teaching, used between classes, and at either end of the day. Other spaces include highly serviced specialist labs, informal science 'workshops', and a new way of using prep rooms that reflects the changing role of technicians.

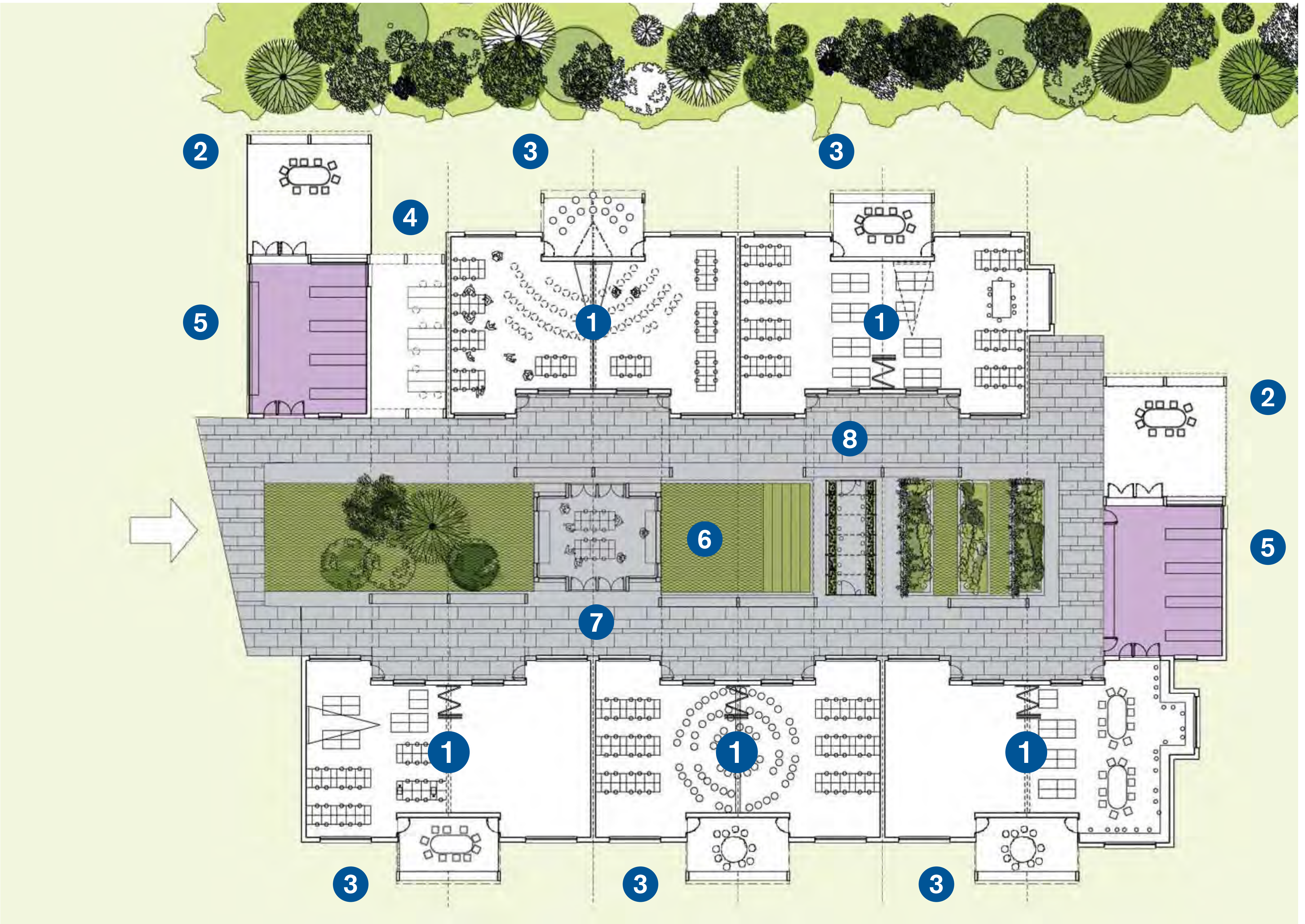
The most significant departure from the conventions for science departments is providing a place for in-house science outreach – in the form of a science discovery centre, placed within the science courtyard. It's a resource centre, taking the place of a laboratory, in which ongoing science experiments and demonstrations can be housed, exposing students to the science being learned in years above and below them, and the world beyond.

"I want to be able to see out of places. I want clean, comfortable spaces that are adaptable too."



Concept plan showing key features of the design

The Faraday team wanted to develop a family of spaces so students can investigate, gather data, learn, hypothesise and explore. They wanted spaces suitable for individual study, public and semi-public areas, and focused not only on formal teaching, but also on how and where students would learn on their own.



A pupil's view

To illustrate how students might use these facilities, let's say they have to find out the current positions of the planets in heliocentric coordinates, and then make a table of the planets' positions every month for the next year. They might make a scale model of the solar system in their design and technology classes, which they then erect in the courtyard. Then they might carry out research in the Science Resource Centre to configure the model correctly and indicate the future path of the planets.

An 'ecliptic column' (a moving sculpture that stays aligned with the solar system as the earth rotates) in the courtyard helps students to relate their model and the school itself to the actual positions of the planets. These interlinked tasks give science a practical dimension and at the same time make it relevant to the real world.

1 Ten paired 90m² laboratories (two labs for sixth form)

There's a series of similar laboratories with separate theory and practical areas to increase flexibility. Labs link together when necessary to form larger spaces.

The college has a range of scales of spaces for learning, with the typical lab design including pockets of smaller space for individuals or small groups. It extends at the back to incorporate a shared external learning space, and the threshold into the lab becomes an informal place for display and observation while students wait for science lessons to start.

2 Two outdoor labs (60m²)

In the past, staff used playing fields or unused parts of the school campus to undertake outdoor experiments. A simple canopy and some services now mean that more external work is possible. This contributes to a wider and more stimulating range of learning environments.

The outdoor laboratories are free from a sense of ownership – they aren't allocated to specific indoor rooms. This means they have the potential to belong to the students, albeit supervised by technicians in the adjoining prep rooms. They also act as a base for more formal outdoor teaching.

3 Five covered outdoor learning spaces

Each pair of indoor labs shares an outdoor learning space, less formal spaces than the outdoor labs. They offer huge potential for teaching, since they act as an intermediate space – not a classroom, yet still close enough to the lab to use lab facilities when they're needed.

Their location between labs means they can bring together different year groups. The spaces can also be used for student project work and are well suited to personalised learning.

4 Staff workroom

Overlooking the courtyard to improve supervision, it provides a connection between staff and students as they come and go through the department. It's next to one of the prep rooms, so staff can be well served by the prep room and work closely with technicians.

5 Two prep rooms

Estover decided to divide the prep rooms into two so they could be positioned around the science courtyard like shop fronts. This means there's good supervision of the outdoor labs for health and safety. It also means each prep room can be paired with an outdoor lab, making the technicians' lives simpler.

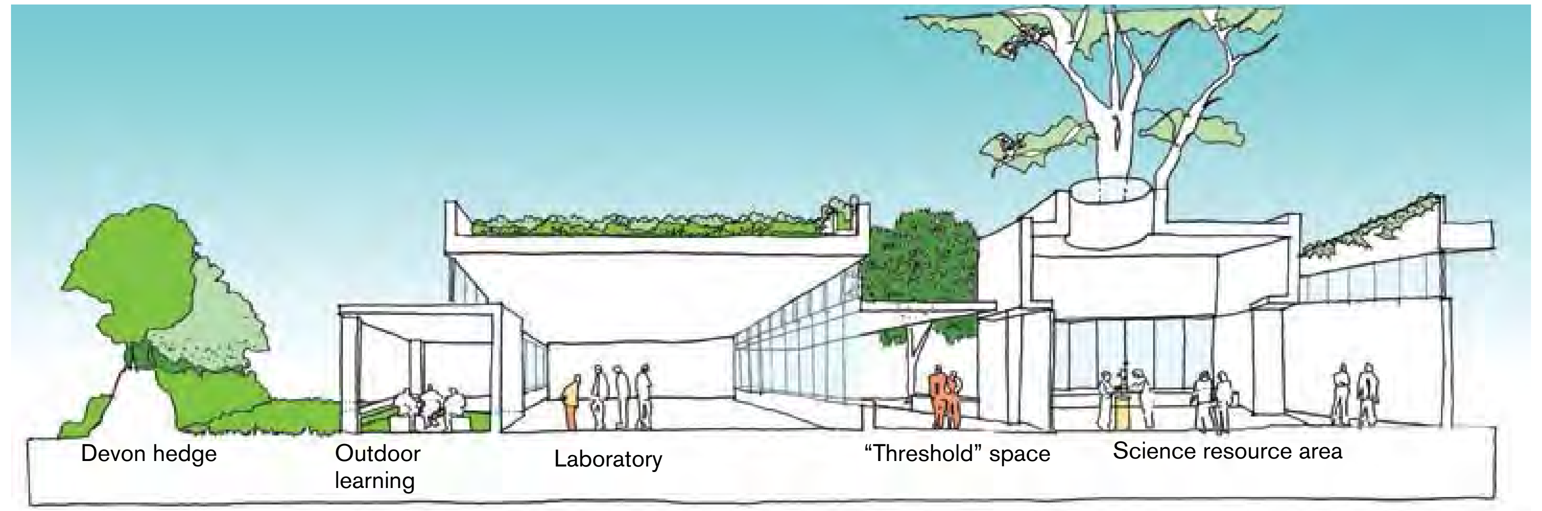
6 Courtyard

This is seen as a living resource for the science department, with the potential to change over time. It can be built with a rich, bio-diverse landscape, including planting areas for student projects and space for technicians to grow experimental crops. It's a democratic space, belonging both to students and staff.

It's scaled for easy supervision – not so large that students can hide away in it.

7 + 8 Science resource centre and greenhouse

These spaces are within the courtyard, making them equally accessible from every lab, and easy to supervise from any of the labs or the prep room.



The Estover designs reinforce the link between the internal science areas and the outdoor environment beyond. There are important physical and visual connections between internal lab spaces, the courtyard and external labs, which should help teachers and students relate their science work to natural processes outside.

The design team aimed to meet BREAM criteria at the same time as supporting curriculum subjects, letting the building act as a third teacher available for students and staff alike.

For example, the building fabric lends itself to reinforcing sustainability lessons – students can see rainwater collected on the roof, tracing its route through the building to the courtyard. The sedum roof not only offers an example of a sustainable, living building material, but also has the potential for monitoring by students over time – so seasonal colour changes and growth can be studied.

Cost commentary

- This scheme makes good use of the available funding to provide learning spaces both internally and externally. In particular the use of outside space and the covered areas represent good value for money.
- The main additional cost items are folding acoustic partitions between laboratories and non-standard fittings and furniture. There is also an additional cost in making the sedum roof accessible to students for observation and study.
- The extra-over cost of the conceptual design (compared to a traditional science facility of 10 labs) is £266/m² of the gross internal floor area. This is at the lower end of the cost range of the extra over-costs that have been identified for the six Project Faraday schools.

CLEAPSS comments

- The flexible walls to the laboratories offer numerous interesting possibilities but must provide adequate sound insulation when they're closed. They also need appropriate fire resistance.
- The central serviced bollard in the laboratories would be convenient for teacher demonstrations – important since the perimeter benches don't easily allow for practical demonstration.

Renewals case study 06

East Barnet School

A variety of science spaces, including a multifunctional demonstration area, have been designed to accommodate both conventional and more radical timetabling.

1241
Barnet
11–18
DEGW

This 3D cut-away shows East Barnet's science accommodation to the right.
Image credit: Building Design Partnership

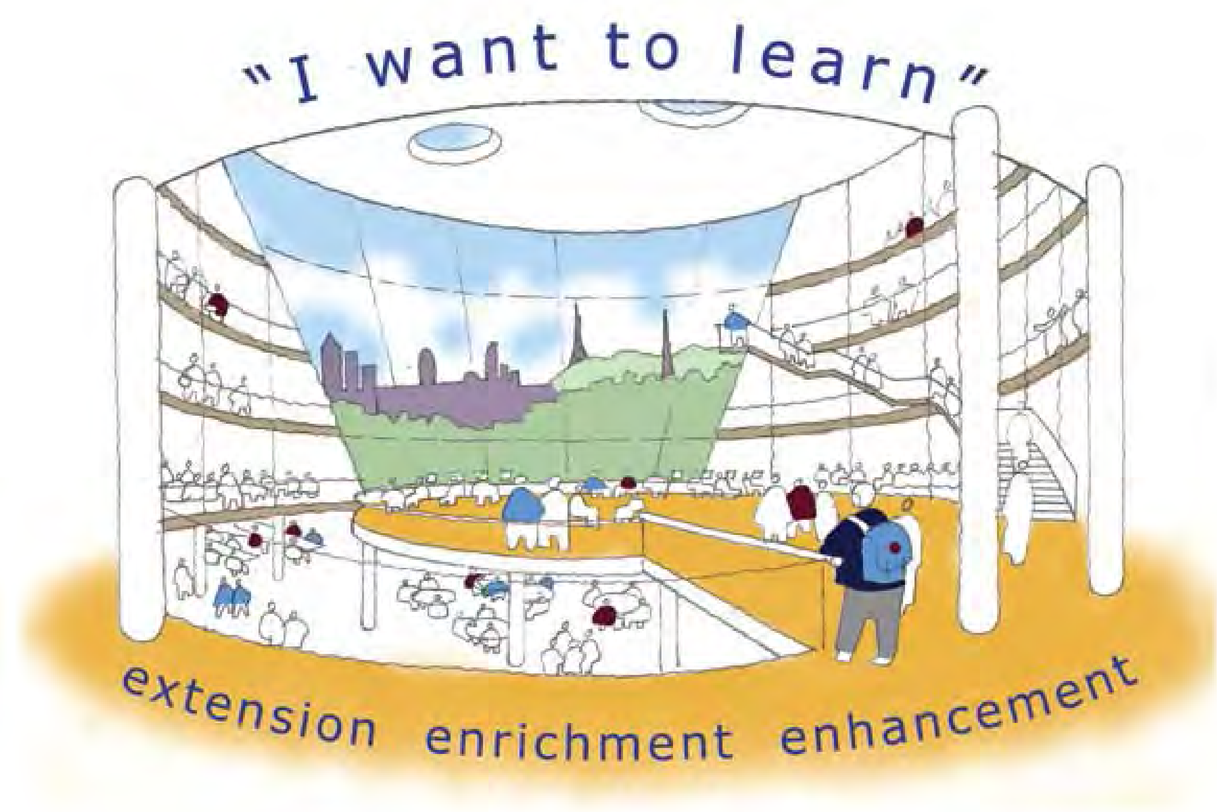


Image credit: Building Design Partnership

East Barnet School's motto is "I want to learn". It aims to inspire and motivate learners, making the curriculum relevant and real. One of the strategies is to bring students to the forefront of modern science: What will consumer electronics do in five years' time? What's happening now in leading science universities?

The school also has high environmental aspirations. It's pushing recycling and plans to make greater use of renewable energy systems – solar and wind. It's also created a school garden, used for growing plants and as a peaceful learning environment in summer.

The focus of the Faraday Team was to design the fit out to accommodate standard classes and triple E (Extension, Enrichment and Enhancement) groups based on the school's conceptual designs. At the time of writing the overall school design is undergoing a process of review and the final design may not be as illustrated.

"We could have a collaboration space where you sit down and talk – a different type of lesson, when you could just discuss something. Not somebody trying to consciously teach something."

The school is pioneering a number of developments to continue to engage students. A key concept, piloted since September 2006, has been its Triple E sessions. Pitched to put the 'wow' back into learning, they include a number of project-based and themed activities and have been such a success that the school plans to continue developing the programme.

Triple E doesn't replace standard classes but builds on the theories learned in class in an interactive and engaging way. It's had a big impact on the types of spaces provided in Project Faraday.

The brief to the Faraday team was to design a science department used differently in the morning and afternoon. In the morning it should function as normal, with classes of 30 pupils in periods of one hour, managed by a single teacher. The design brief specified at least nine teaching spaces to allow up to nine classes to use the science department at once (but not all classes needing access to serviced lab equipment at the same time).

In the afternoon, East Barnet will continue its Triple E project-based learning. Groups can work in a number of different ways, either circulating between activities or performing the same activity for several weeks. The school therefore needed a 'group-centred' space that can accommodate different activities – large-scale lectures, inspirational talks or demonstrations to 100 students at a time.

To meet this need the architect reallocated the area provision given in the initial schedule of accommodation to incorporate a large demonstration area.

East Barnet also wanted to make the most of new virtual reality teaching packages. The school envisioned students able to 'pilot' their way through the solar system and the stars, or experience moving through the human body, or manipulate molecules to see how chemical reactions actually happen. They foresaw using digital technologies to extend opportunities for learning – for example, providing video on demand through its own virtual learning environment and enabling video conferencing with other schools and universities.

The workshops to refine elements of the design used:

- Briefing cards – DEGW uses this specialist tool to engage with stakeholders. At East Barnet the cards were used with students, the science faculty, non-science teachers, senior management and governors to help understand the aspirational learning experience in the school.
- Lego serious play – five older pupils, the head of science, and the head of technology, were taken to BOX, a 'creativity and complexity space', and used a Lego serious play facilitator to help express complex ideas about learning science as a group.

A strategic approach was taken to writing the brief for the science spaces, focusing on understanding the People (the experience of learners), then the Process (how people are to learn), and finally the Place (the spaces needed to support that learning). The procedure (described in more detail in the Process section, p10), included:

- Understanding the experiences learners should have in science at East Barnet
- Exploring the school's organisational model to underpin the experience
- Considering the spatial implications of the organisational model
- Identifying and prioritising key teaching techniques the school will use
- Mapping those teaching techniques to a spatial model
- Testing the key characteristics of spaces those teaching techniques will need
- Creating settings that respond to those characteristics
- Combining the characteristics and settings to plan the space

Students said they wanted to 'do their own thing', with a real 'wow factor' to science. Some wanted to be able to experiment and get things wrong, and to try other experiments as a result. They saw this as 'real' science, and that learning science should be done through 'doing real science', not just replicating existing experiments.

The timetable division between morning and afternoon use, and the school's vision for science, had two notable spatial implications – designing a department that functions as an integrated whole, and providing nine teaching spaces that could be arranged in a 'teacher-centred' way (with learners facing forward).

The project team considered the different teaching methods used for science and what sort of accommodation would support these best, planning them into a zone layout.

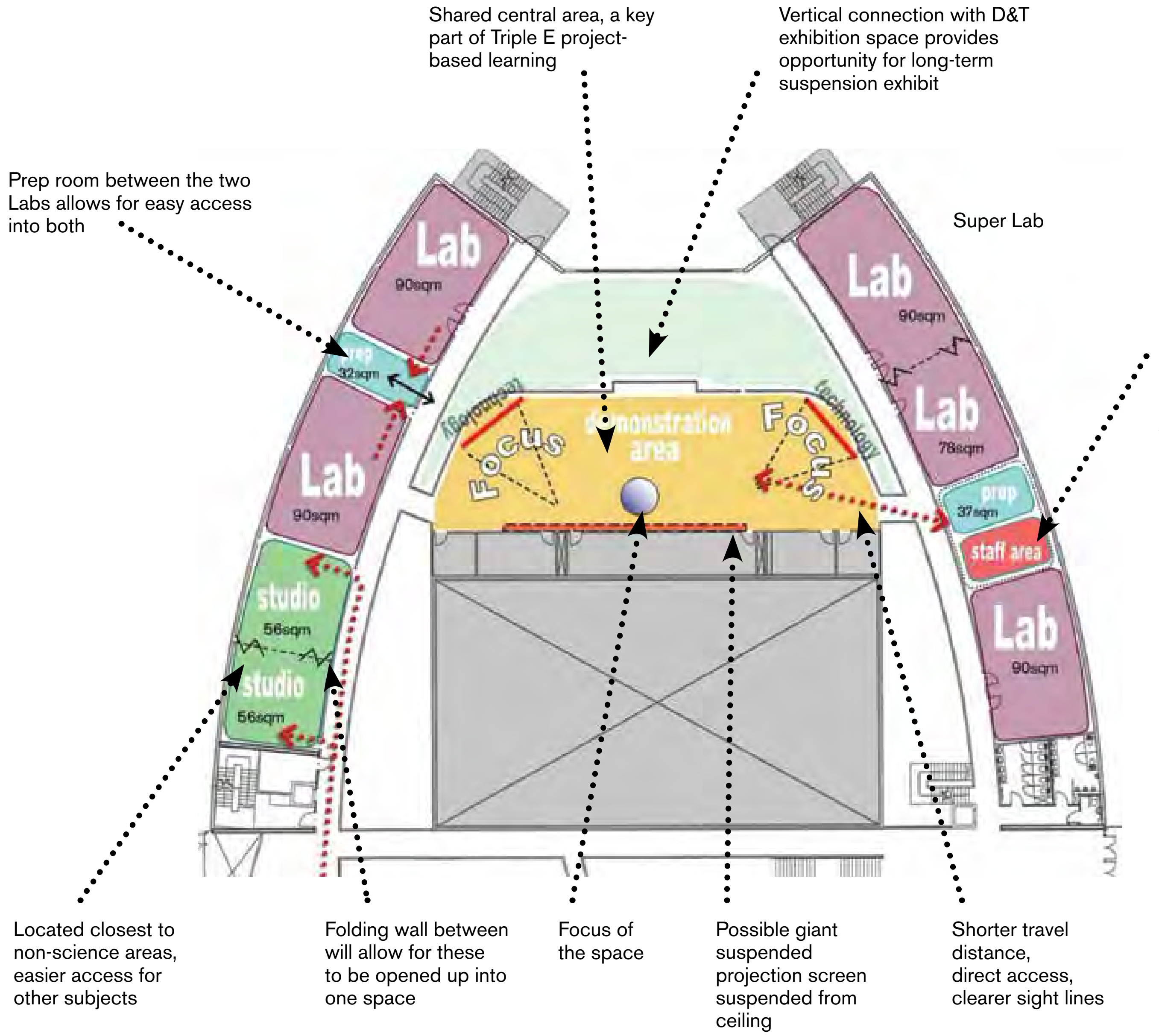
This project team reconfigured space from the traditional model for science facilities used by the local authority, to provide a much more varied set of learning facilities but still with the same total floor area.

The tables and pie charts show the final zoning at the school. The shell is untouched from the original design and shows two wings of specialised teaching spaces and support space, connected by a demonstration area.

Using the buildings and grounds for learning

The school was keen to make every section of its new building an education resource in its own right – a walk through a faculty corridor should show how each area of learning has contributed to human development. It must also encourage intrigue about future developments, so students receive pointers about future technology innovations.

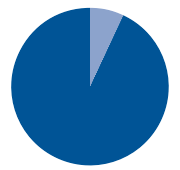
The final aspect of the vision saw the school using the school grounds to bring students close to nature – the 'natural lab' outside could present unrivalled potential to learn about animals, birds, insects and plants.



Concept plan showing key features of the design

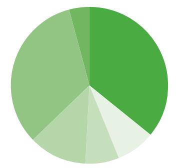
Pre-Faraday schedule of spaces

Space	no.	Size(sqm)	Total
Biology lab	4	90	360
Chemistry lab	3	90	270
Physics lab	3	90	270
Prep room	6	12	72
			972

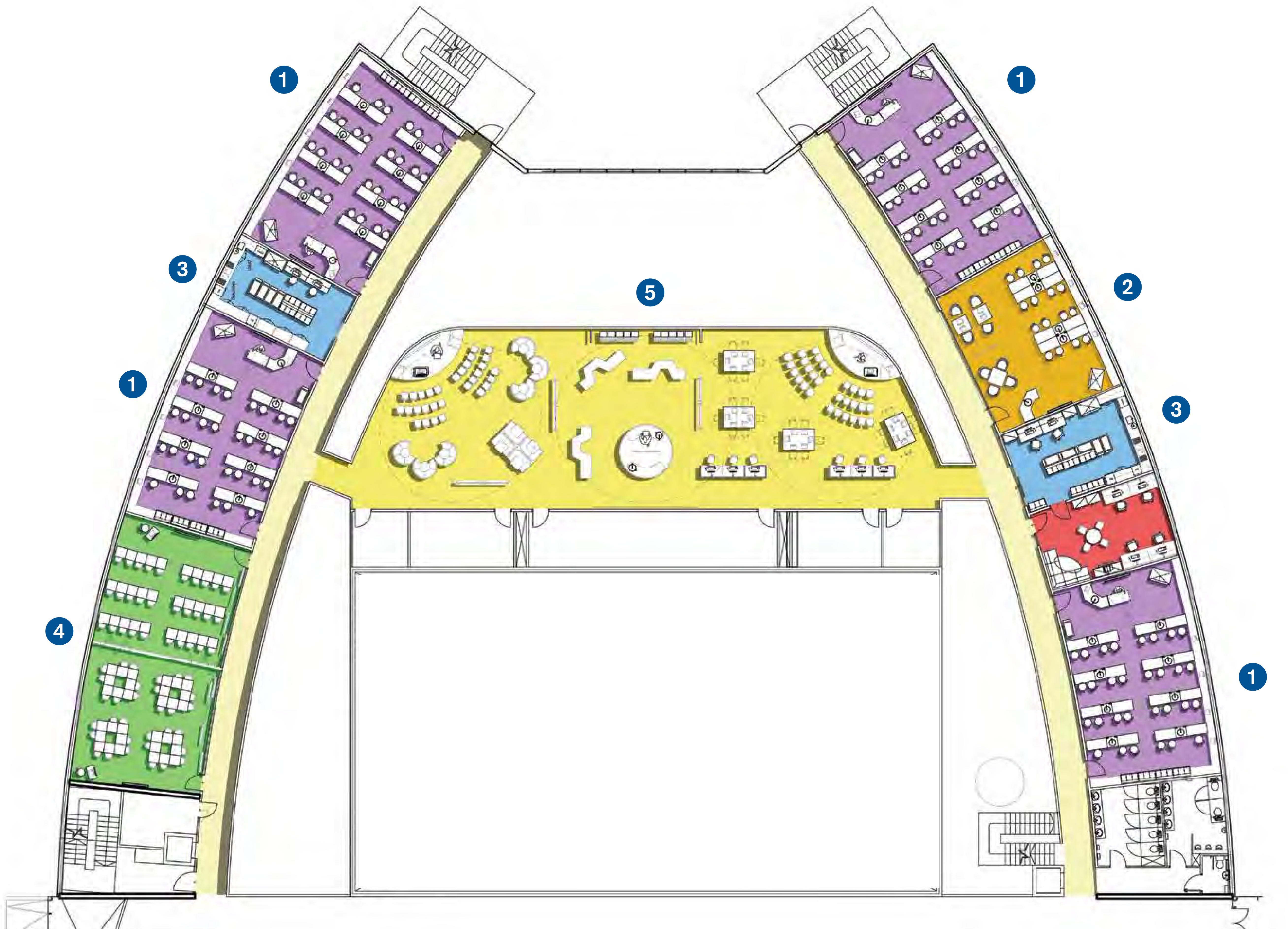


Project Faraday initial schedule of spaces

Space	no.	Size(sqm)	Total
Typical labs	4	90	360
Small labs	1	78	78
Prep rooms	2	34	68
Studios	2	56	112
Demonstration space	1	319	319
Staff space	1	35	35
			972



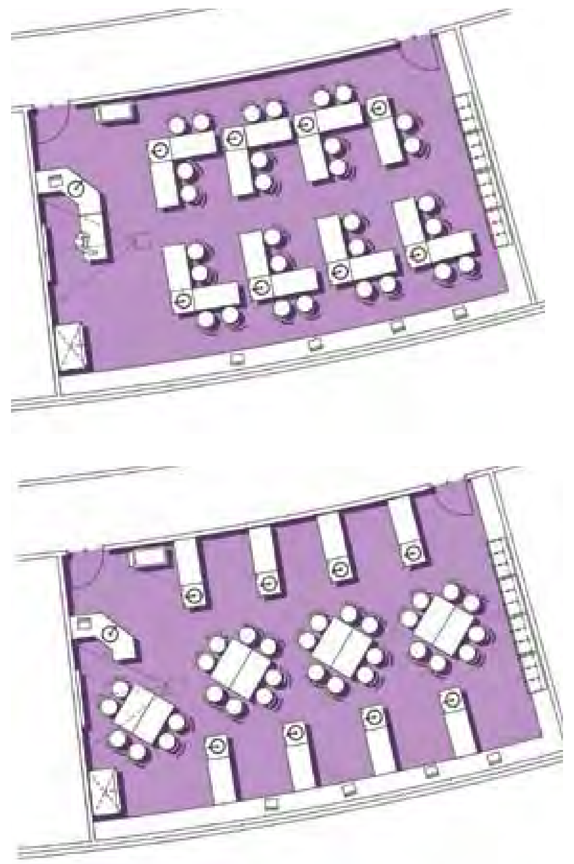
The principle spaces in East Barnet's proposals are four traditional labs, one 'superlab' inspired by commercial science, two science studios and a large demonstration area. The demo area is big enough for a half year group, and has three zones for different activities.



Detailed floor plan

There are nine potential teaching spaces that could be used at any one time:

1 Four laboratories (90m²)
The design brief for regular labs was to provide teacher-centred spaces where all learners face forward and the teacher has a demonstration area. The project team found that fixed, serviced bollards were the most cost-effective yet flexible option, and planned them so that a number of layouts would be possible, as shown. The designers have specified mobile fume cupboards, but if the school decides against them, other fume cupboards will be substituted before fit-out is complete. Storage is at the rear and side of the labs, providing extra bench space.



Alternative lab layouts

2 One 'superlab' (90m² + 78m²)
Influenced by the science industry, primarily a science lab, with a mixture of experiment desks and breakout spaces for research, brainstorming and meetings. It will have the atmosphere of a club, and a glazed wall will make the lab visible to younger learners, establishing an area that younger students aspire to use. An acoustic partition separates the small lab from the standard lab, making it a fully functioning research lab like a university's.

3 Staff room (35m²) and two prep rooms (34m²)
Located together for easy interaction and coordination between technicians and science teachers. The staff working area is designed to provide hot desks and soft meeting facilities or breakout space. The prep room is equipped to meet BB80 guidelines. There's a second prep room in the south wing of the department.

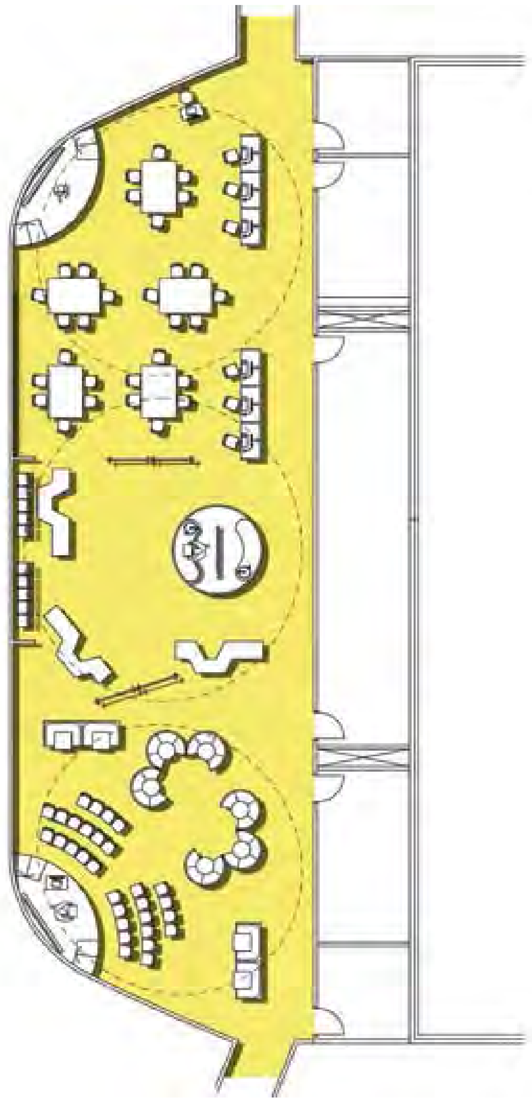
4 Two science studios (56m²)
Two interconnected theory spaces, each for 30 students (equivalent to non-science classrooms in the school), with no gas or water services. Moveable furniture allows for flexible room layouts, and a moveable partition allows this space to be opened up into one large area. The designers envisage the partition as a whiteboard to allow extra writing surface. The wall facing the corridor incorporates panels for constantly changing displays.

5 Science demonstration area (319m²)
A large area with three zones, in a double height space. The school needed enough room for a half year group to watch demonstrations or lectures on a large screen – the chairs can be used at the group tables or stored in a special area along the central part of a balustrade. This space is shown in more detail on the following page.

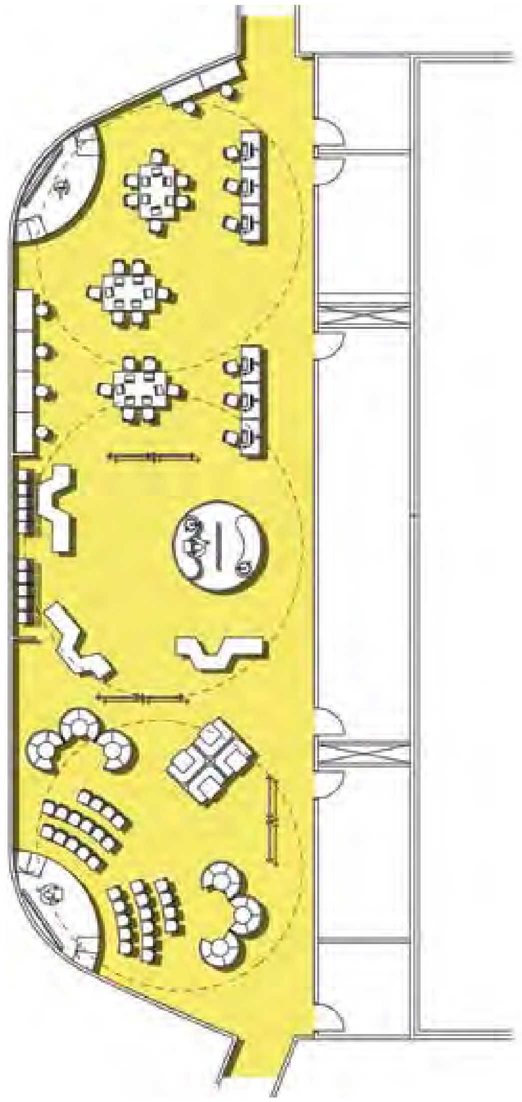
The partition between studios can be open or closed

Service bollards are fixed but loose tables allow for a variety of room layouts

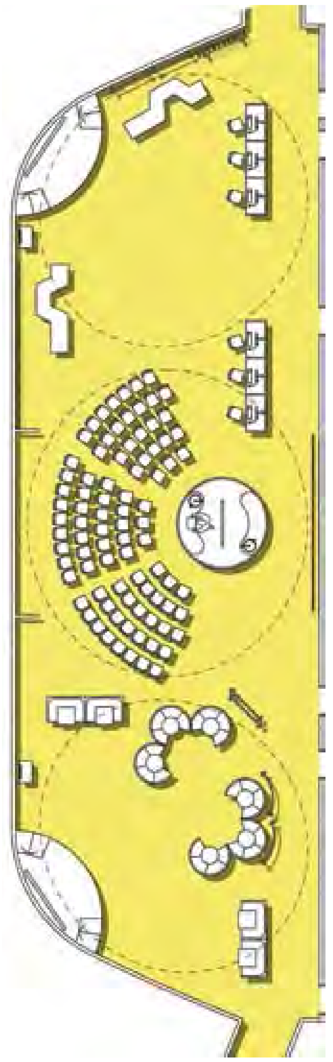
The small lab combining relaxed seating with more formal science benches can be openend up to the adjacent lab to form a superlab



Furniture can be arranged differently in the science demonstration area. Here the north end is used for group work around tables – with some using laptops – while the south section is used for small group and independent working. Mobile whiteboards add flexibility.



Here the demonstration area is set up for using laptops in the north section and small group discussions in the south. The central section may be used for individual work by students from either north or south sections.



Here the demonstration area is used as a single space, set up so that half a year can see a presentation, perhaps from a visiting scientist. The chairs shown are stored along the left hand wall when not in use.

"We want our building to be beautiful and elegant, to symbolise nature and the organic in some way, and it needs to be able to grow. We want the excitement, the fire and the passion of a volcano."

The south studio of the science demonstration area, group snugs, mobile whiteboards, discussion snugs and presentation platforms.

The north section has moveable shelves, tables and individual study desks, so it can be used in many different ways.

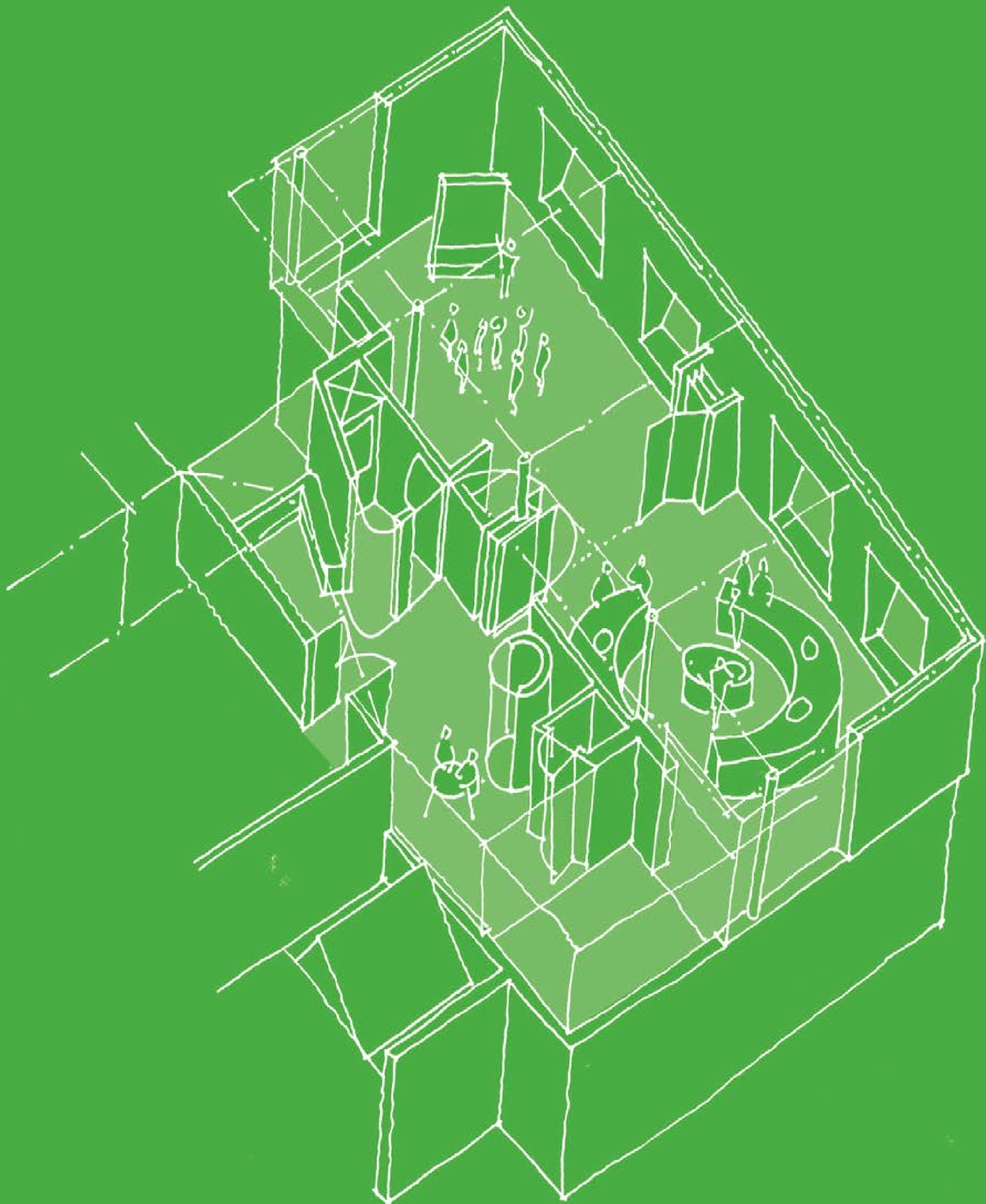
The mid-section, with demonstration podium, projection screen and chairs laid out for a group presentation. A phantom grid on the floor of the periodic table allows quick alignment of chairs.

Cost commentary

- The main additional cost items are folding acoustic partitions between labs, enhanced services and services equipment and some non-standard fittings and furniture, especially in the central area. The additional cost includes ceiling domes in the central area that define individual learning zones and improve acoustics in a large area.
- The over-cost of the concept design compared to a traditional science facility of 10 labs is £166/m² of the gross internal floor area. This is at the lower end of the cost range extra costs identified for the Faraday schools.

CLEAPSS comments

- Teachers will have to swap rooms, probably quite frequently, to allow for a mix of practical and non-practical lessons.
- A teacher's mobile bench – with liquid petroleum gas and other services – is being considered for the science demonstration area. These benches tend not to be well liked. An alternative might be to provide one or more fixed free-standing serviced bollards with adequate and secure provision to shut off the mains services when they're not in use.
- The school should resist the temptation to move trolleys through the science demonstration area – furniture or equipment may well impede the safe movement of materials.
- Having two prep rooms creates security issues that are less likely with a single prep room. Technicians moving between rooms may mean that either room is left unlocked and unsupervised even for short periods of time. Staff must remain vigilant to ensure this doesn't happen.



Section 04

Design proposals:

refurbishments

This section describes the other six projects carried out in Project Faraday. These are very varied projects involving adaptations and extensions to existing science facilities.

The schools and their designers worked through a similar process to that described in Section 01 – research, vision, strategy, and learning and teaching practice – but the Faraday Teams were much less closely involved than they were in the 'renewal' schools and in some cases designers had to work within the constraints of an existing building.

Like the renewal schools, these designs should not be seen as a template to apply in other schools. Instead, they are intended to show what can be achieved even in quite small building projects, and how even modest changes can provide inspirational settings.

Refurbishment case study 01

Cramlington High School

1600
(from September 2008)

Northumberland

11-18
(from September 2008)

Waring & Netts Partnership

£1,950,000

Cramlington High School is a specialist science college which, because of a change in intake from 13-18 to 11-18, is being remodelled to accommodate extra students. A new block for Years 7 and 8 – the 'junior learning village' – is being built and will include a 'science learning plaza'.

The school has an innovative ICT strategy, employing a team of web designers to work alongside staff, producing high quality web-based resources for learning and teaching.

The school is launching the enquiry-based science curriculum in Years 7 and 8, based around:

- scientific thinking
- applications and implications of science
- cultural understanding
- collaboration

Students will be researchers, explorers, hypothesisers, experimenters, problem solvers, and solution providers and learn the relevance of science in everyday life.

Cramlington also wants to get teams of teachers working together with larger groups, enabling a shared and more flexible (and personalised) response to learning and teaching. There will be three Year 7 and 8 groups working simultaneously in half day sessions.

A flexible facility was needed for this new way of learning and teaching.

The design encourages a hands-on, practical and exploratory approach to science in a series of learning zones for different activities and learning styles. It also builds on the school's ICT strategy, putting ICT in the hands of the students, and using the building fabric as a 'third teacher'.

The school, their architect and the web design team worked closely together, drawing on visits to the Eden project, other schools and research into enquiry-based learning.

The design of the junior learning village is based around the concept of a village street, which connects different parts of the new building but also provides a place for cross-curricular learning and inspirational display. Within the Village, there are three main areas for science:

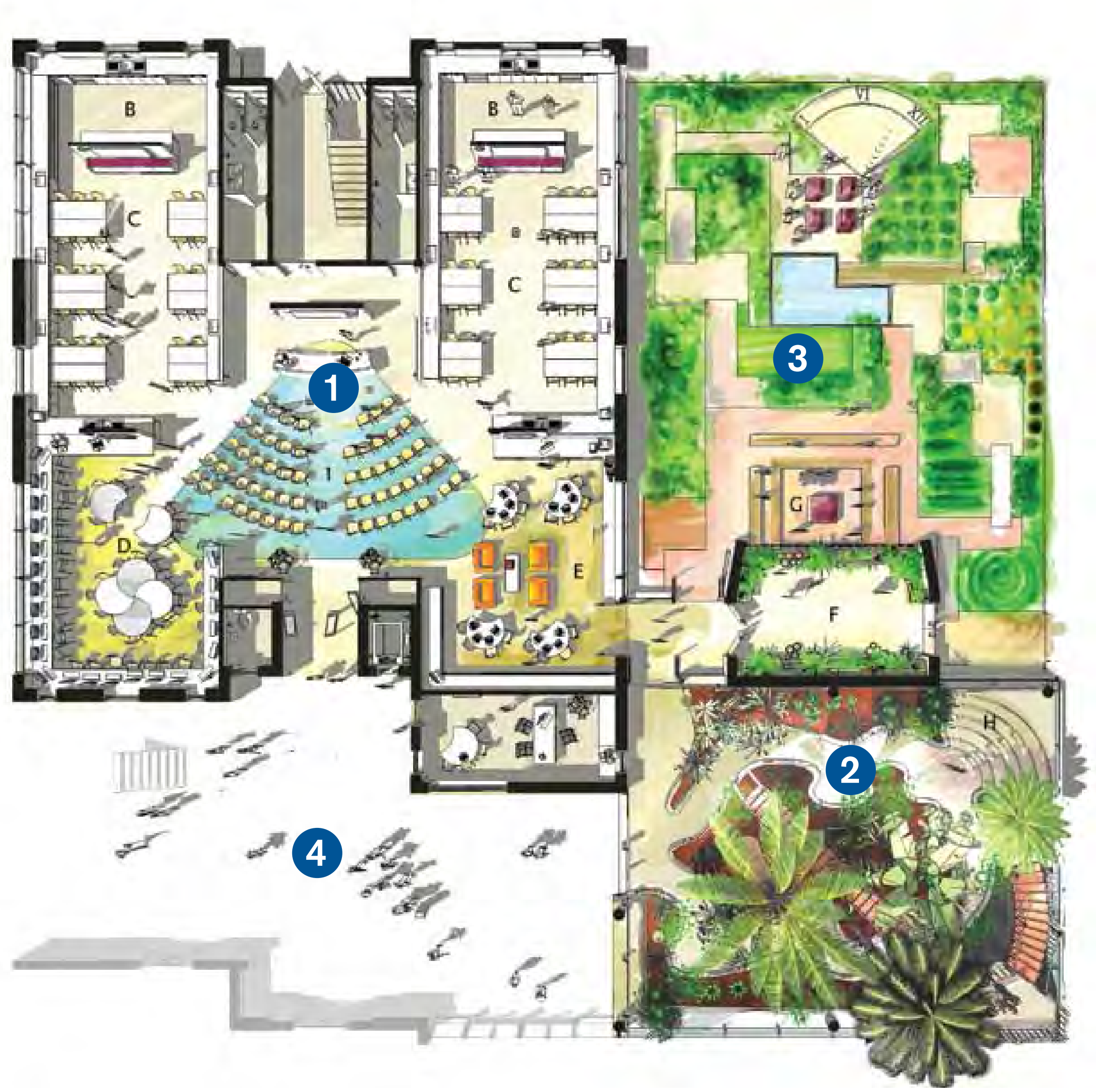
1 The science plaza
A large open plan space for up to 90 students, where students will work on open-ended science projects, supported by a team of three teachers. There are flexible zones for different activities – research, wet work, demonstrations, group collaboration, presentations and group sizes. The designs aim to address the familiar acoustic issues arising from open plan facilities by using free-standing dividers between the zones.

Students will use ICT not only to research and present their ideas but also to reach out into the wider community, potentially collaborating with students and professionals from around the world.

2 A two storey bio-dome, or 'biome'
A glass construction which recreates a Mediterranean environment, where students can study plants and insects not native to the north east of England. The biome provides opportunities for long and short-term science projects, as well as offering a whole-school facility for cross-curricular projects.

3 A science garden
Includes a covered external classroom, a propagation area and areas to cultivate native species.

Elsewhere in the school, photovoltaic panels and a wind generator will together generate enough energy to power a small water feature and fountain.



1 Science learning plaza
2 Bio-dome
3 Science garden
4 Link to junior learning village

A Demonstration and review ($101m^2$)
B Preparation and storage ($29m^2$)
C Practical zone ($204m^2$)
D Resource & ICT learning zone ($60m^2$)
E Discovery zone ($60m^2$)
F Propagation workshop ($30m^2$)
G Outdoor learning base ($17m^2$)
H Indoorl learning base ($14m^2$)

A day in the life: student topic – water

In one corner of the science plaza a small group of students selects glassware from the prep room and sorts though the well-equipped junk box. They're working collaboratively to solve real-life problems of collecting, purifying and distributing water in developing countries.

Students in the biome learn about eutrophication (when water has too many dissolved nutrients in it, which spurs algal growth). One is designing long-term experiments to test specific hypotheses.

In the science plaza, other students are contacting their peers in schools abroad.

Elsewhere, students are engaged in a web quest investigating the plight of Nicaraguan lobster divers, many of whom become disabled from the bends.

The two store bio-dome (below) will be a lightweight structure where students can examine temperate plants and insects, safely protected from the elements.

Refurbishment case study 02

Weydon School

1100
Surrey
11-16
NPS Property Consultants, Brighton
approx. £800,000

Weydon is a specialist science school offering a range of courses, including vocational. The school believes that how learning takes place is as important as the outcome. Science courses are very practical and include debate, drama and role play. They embrace visual, kinaesthetic (involving student movement) and audio learning styles, with ICT fully incorporated.

The school wants the new science suite to inspire and enthuse all who teach and learn in it, with the flexibility for both whole-class learning and opportunities to meet in small breakout groups. It's hoped the suite will be a catalyst for transformation across the school.

The design, a collaboration between staff, students and designers, supports rich practical investigation and experimentation as well as creative approaches to exploring science, such as drama. The designers set out to maximise the space available for learning, including using external spaces, quiet places for reflection, and spaces for small group discussion.

The school site has very little space to build on, so the new science suite will be built as the first floor of a single storey block, adjoining existing science facilities. The design is based around a rainforest theme, creating an 'Eden project' effect, with tropical plants and views out to the countryside on one side and to the outdoor teaching area on the other.

The science suite will include:

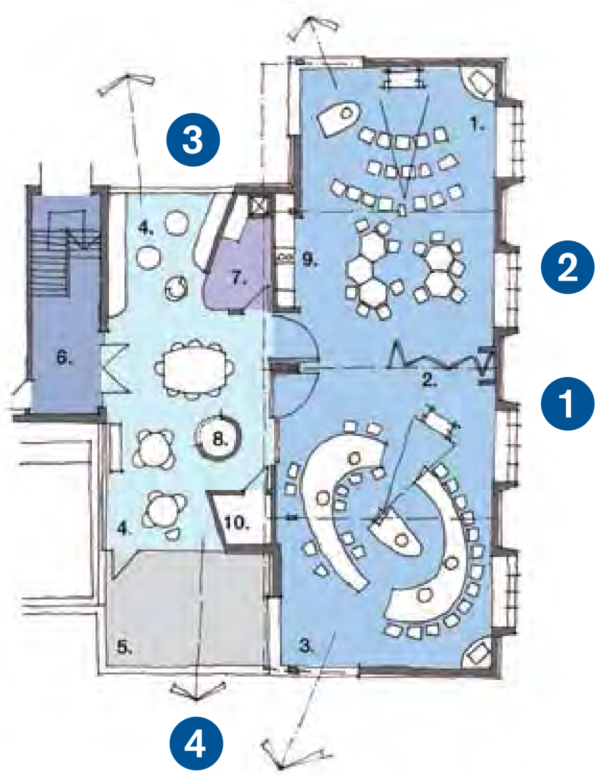
1 A fixed lab zone (98m²)
A highly serviced laboratory with two semi-circular benches for demonstration and practical work as well as class discussions in the round. An acoustic flexible wall means the laboratory can open out into the adjacent studio.

2 A science studio (88m²)
A lightly serviced and flexible space to support a wide range of scientific activity – from light practical tasks to drama. It has a demonstration facility (with a video projector so everyone can see experiments) and a flexible learning area for ICT use, discussion and debate. Height-adjustable tables allow both seated and standing work. Furniture will be light but robust so it can be folded away to clear the space for large group activity and/or use by the community. In the kitchenette, students can work on small scale food science topics such as making beer and yogurt.

3 A zen zone
A welcoming and versatile space with comfortable sofas and chairs, for problem solving and small group discussion as well as support work and community learning. Glazed walls allow supervision from adjoining labs.

4 External deck
The school is developing plans for a glasshouse to grow a range of plant life and crops for testing in the kitchenette, and a vertical garden in front of the terrace, where students can study plant types and observe nesting birds and bats.

Sculpture and interactive experiments in entrance areas close to the science department will ensure that science is celebrated across the school.



Conceptual floor plan.

Refurbishment case study 03

Kendrick School

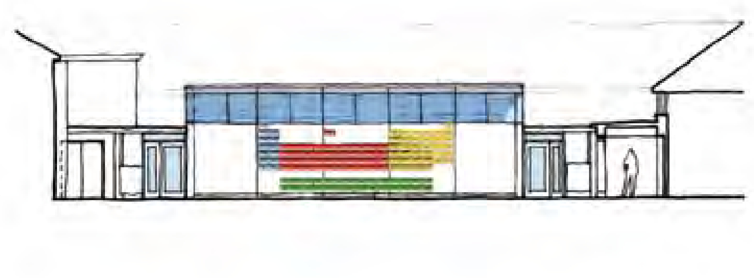
700
Reading
11-18
PB&R Design Services
approx. £880,000

Kendrick is a girls' grammar school with specialist status in science and mathematics. It recently led a ground-breaking federation with Reading Girls' School and Thames Valley University. The existing science facilities don't meet the school's needs – there's a lack of practical facilities and not everyone who wants to take A-level science can do so.

Kendrick's philosophy is for students to enjoy independent creative learning while acquiring a great depth of subject knowledge, skills and understanding. Students should have opportunities to study 'real' science – including environmental issues – in local, national and global contexts and to make links between science and other curriculum areas.

The design rationale evolved through a series of workshops, with teaching and technical staff, students and the architects considering the issues described in the Process section. Before the workshops, all staff completed a questionnaire which helped to focus on the key features required and aspirations for the future. The consensus was that accommodation was needed for the following activities:

- Experimenting, researching and debating – including individual practical work and private study
- Observing and presenting – including the ability to create a larger space for presentations by outside speakers, visiting schools and family science days
- Thinking, documenting and reading – quiet settings, some with enhanced computer access and some with comfortable chairs
- Making – including the ability to accommodate large models, and access to a covered outside area to include interactive displays


View of interactive wall in courtyard.

The only place for the new science spaces is in an existing courtyard. The new facilities will include:

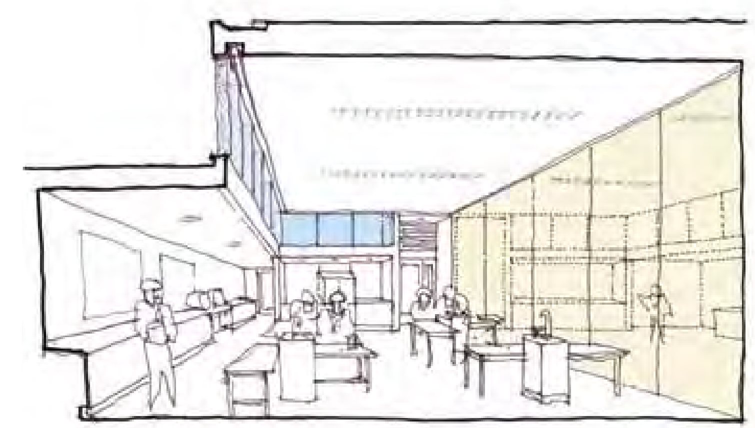
1 Two multi-purpose laboratories (87m² and 92m²)
Linked by a sliding wall to create one large lab for presentations and community events.

2 A large prep room (38m²)
Windows will allow students to see scientists at work. A fume cupboard between the prep room and one of the labs will give students a good view of experiments.

3 A multi-purpose seminar room (22m²)
Linked to the prep room, for discussion work, meetings and research. ICT facilities provided.

4 A terraced science garden
Has direct access from both labs and provides a sheltered space for outdoor learning and teaching, a focal point for environmental education. It will have a sun path dial, rainwater butts, a pond and a habitat area. Interactive displays in the corridors and outside will put classroom science into context in the real world.

Sustainability features are being considered. The school is working with five other schools, each one using different sustainable technologies. They will all share data about their experiences.


View of one of the laboratories.

Refurbishment case study 04

The Mary Webb School and Science College

604
Shropshire
11-16
Simmonds Mills
approx. £1,000,000 (plus £80,000 for ICT and turbine)

The Mary Webb School is a small comprehensive with specialist science status in an area of outstanding natural beauty. The school has a strong culture of working with the local community and partner organisations such as the Forestry Commission.

Greater engagement and enjoyment of learning is one of the school's principal aims. And making science more real and relevant to learners, so that all students have the skills that equip them for 'science citizenship', will make this a reality.

To support these aims and embrace the Government's commitment to sustainable development, the school wants to create an 'eco-lab' in the grounds. It will be used by students and the wider community to help them understand environmental issues better.

The school carried out a consultation exercise with students, parents, governors and the local authority to look into the feasibility of creating the eco-lab. Students prepared a successful bid to the Youth Capital Fund for a grant of £100,000 to support the scheme.

The building will support science learning in two key ways:

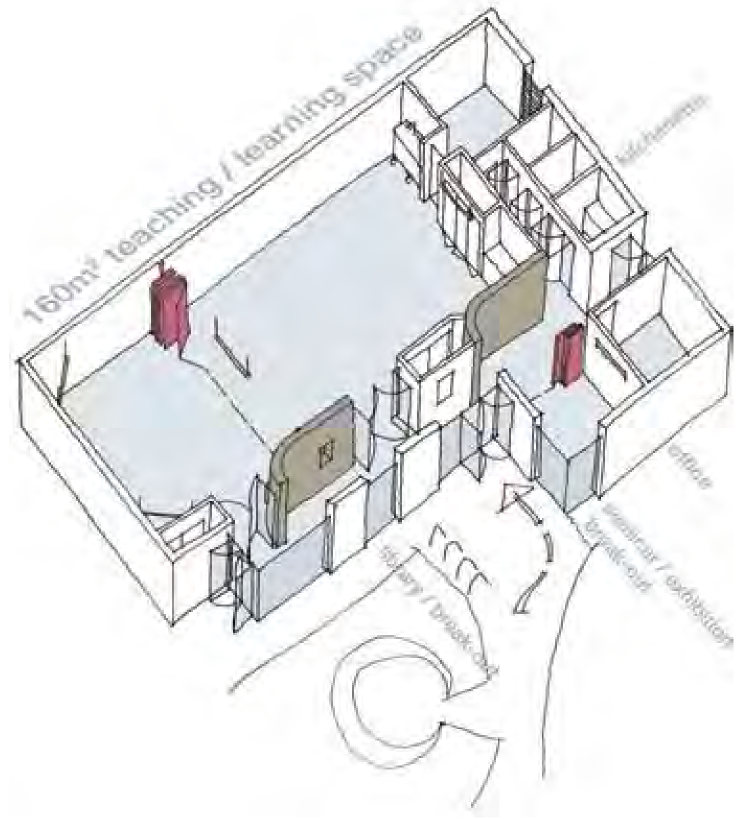
- as an exemplar of environmentally sustainable practice
- as a centre for educating young people and adults about the environment and sustainability issues

The eco-lab will be an inspiration in itself, showcasing options for minimising environmental impact. It will be built to AECB Silver standards, resulting in a minimum of a 75 per cent reduction on average CO_2 emissions. Wherever possible, the building will use locally sourced environmentally friendly materials and the details of construction (insulation, materials, services) will be visible to students.

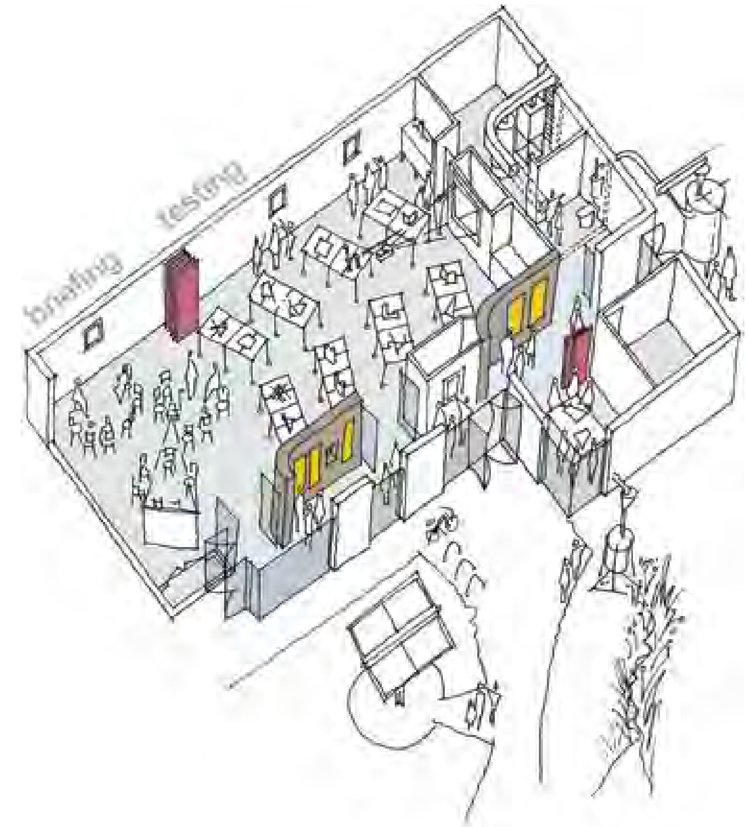
The building will also demonstrate renewable energy sources like wind power, solar panels and photovoltaic cells, and rainwater harvesting and recycling will be incorporated. There will be extensive passive energy features such as a high thermal mass with passive cooling, and natural lighting. There will also be heat recovery and exceptional insulation – avoiding thermal bridges will conserve heat energy.

As a study centre, the eco-lab will enable the school to make wider educational use of the ecology, geography and history of its surroundings. In particular, students will be able to engage in problem solving activities involving real sustainability issues. They will be able to capture and analyse live data in terms of energy and water harvesting usage through the building energy management system and build up a database of information about the way the building performs.

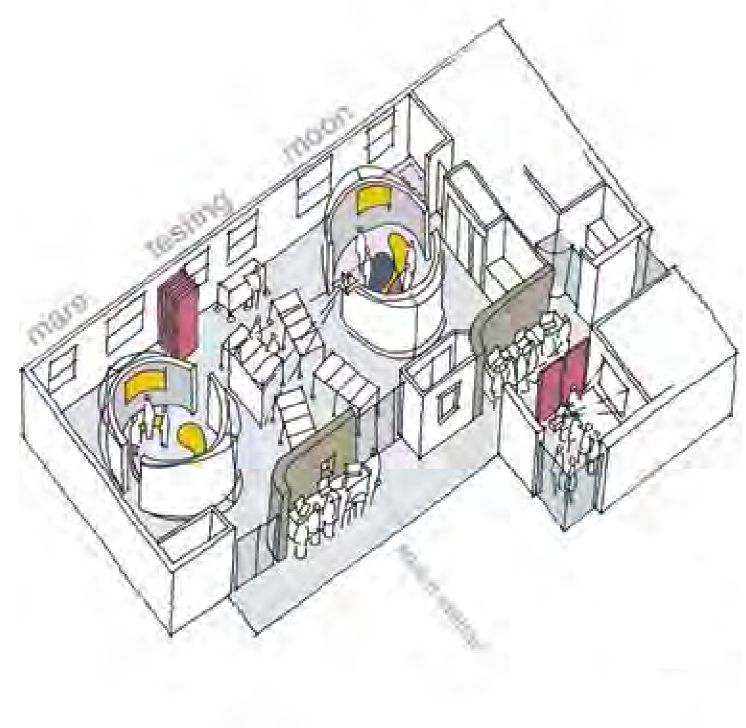
The building, which can be divided into one large and one small classroom, is separate from the existing school but close to the present science block. It's also close to the public library, bridging the gap between school and community. Large-scale experiments will be incorporated into the landscaping.



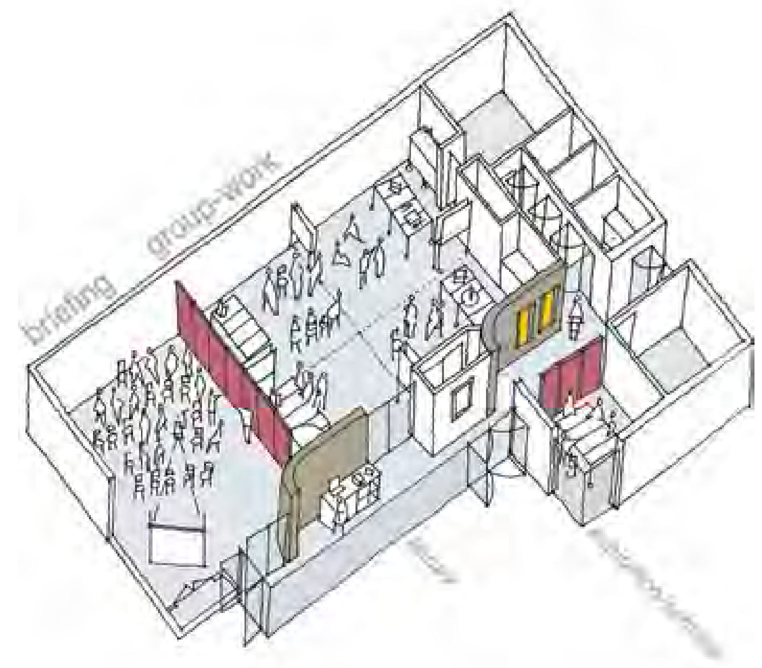
Cut-away view of the eco-lab shell showing key features: a large multi-purpose space with storage walls, breakout space lined with rammed-earth walls, small quiet rooms. The optional layouts shown here demonstrate the centre's flexibility.



The main room is set up to learn about sustainable buildings with one zone for briefing and discussion and another for testing materials. Interactive display in the breakout area is visible on entry. Sustainability features are easily seen by those using the centre.



The whole building is set up for a special project where students play members of a space exploration scheme. Inflatable 'pods' are used to create different environments and 'space stations' are set up in the breakout area.



The building becomes a field centre. The main room is divided into two spaces – one for briefing about the local habitat and one for analysing samples collected locally. An exhibition in the seminar room and IT resources in the breakout area support independent study.

Refurbishment case study 05

The King's School

970
Peterborough
11-18
Saunders Boston Limited
£1,175,000

First floor plan

The King's School is on a tight site close to Peterborough city centre and has a 340-student sixth form. In 2003 it became a specialist science college and has developed strong links with its partner schools and industries. The science department believes that making science more relevant to the world around us, and using real world applications, is important to understanding everyday experiences.

The school wanted to extend practical work, linking it to acquiring and analysing data, and to enhance the use of digital video and audio.

Data acquisition is to be embedded into the design of the building so students can measure a wide variety of parameters that affect the performance of the building.

1 Reflection zone
This allows students to develop video/audio productions and to discuss their work in groups, as well as acting as a small digital cinema.

2 Resource centre
A space with books and ICT for independent research. Sensors built into walls and windows will measure energy consumption, heat flow and stress.

3 The Faraday lab
Created by adapting an existing lab to provide a more flexible space, which has projection from the front and the side, and zoned lighting. Fixed furniture and services are restricted to the perimeter, practical work is possible using tables at 90° to the perimeter bench. 'Surround sound' will allow teachers to recreate experiences such as being in a rainforest.

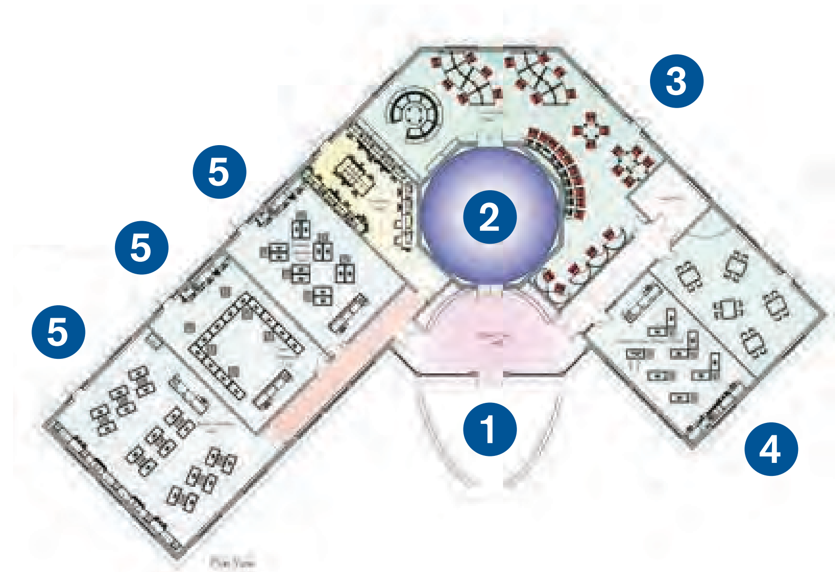
4 ICT zone
On the ground floor, an existing ICT room has been opened up to provide a more flexible and accessible resource which doubles as a conference area.

The school hopes to work with Armagh Observatory to build a human orrery (which shows the relative position of planets in the solar system) in the school grounds. This collaboration will also allow the school to develop external experimental areas and GPS-based learning zones using palmtop computers.

Refurbishment case study 06

The Priory LSST

1750
450 of them in sixth form
Lincolnshire
11-18
Lindum BMS, Lincoln
approx. £1,400,000



The Priory LSST is a large comprehensive, which has been a technology college since the early days of the specialist schools movement. It's also a designated Training School.

The school wants to make all science teaching inspirational to tempt increasing numbers of students to study the sciences post 16. The proposed sixth form science block will create:

- a state of the art flexible teaching and learning environment for post-16 students, with a dedicated resource to support independent learning
- a resource for partner schools and the community

The new science block, deliberately sited at the front of the school, reflects post-16 science as a dynamic experience, allowing both staff and students to work in different environments, with the appropriate resources on hand to support their learning. The new facility will provide:

1 An entrance foyer (56m²)
With a range of scientific activities, such as a thermal camera, a prism, a large lava lamp and computer-generated displays.

2 Galileo planetarium (65m²)
The school has worked with the local astronomical society on planning this space, which has a constant display of the changing night sky. It will be made available to other schools and the wider community for performing arts as well as science activities.

3 The Marie Curie Museum and Library (148m²)
A resource area for independent study and group brainstorming. Displays will be linked to current scientific issues.

4 The Michael Faraday lecture theatre (120m²)
Two spaces (one a serviced practical area and the other multi-purpose) can be used separately or together for demonstrations and lectures, including from visiting specialists and for staff training sessions.

5 Three fully equipped practical rooms (252m²)
Fixed service bollards and loose tables allow students to work in class-sized groups, smaller groups or as individuals on a range of tasks.

Outside there will be a dedicated nature garden, a speaking tube, wormery, giant working gears and a Faraday cage. A wind turbine and solar array will be used to teach about sustainable energy resources.

Section 05

Interactive experiences

The Faraday teams were charged with developing a series of 'interactive experiences' in parallel with their design proposals. These experiences are learning activities that will inspire students and leave a long-lasting memory of whatever science concepts the experiences were designed to convey.

These activities are intended as prototypes, to be used and evaluated in the Faraday schools.

Most of these experiences have a strong practical dimension – not least because students remember what they do themselves better than what they are told, or read, or see on screens. They also specifically encourage students to interact: with each other, with the natural world, or with students and professional scientists outside school.

They are varied in type and scale, and they were developed to convey complex scientific concepts people often find hard to understand.

Many of the interactive experiences have an information technology component. Some are integrated into the school building or grounds, making the concepts real and grounded for students, which often makes abstract ideas easier to grasp. Many of them are also intended to support individual or small group learning, which can improve motivation and encourage students to do more for themselves.

Some of the experiences also reinforce cross-curricular project work, and some encourage students to work outdoors. Some are narrowly focused on specific aspects of the science curriculum, while others have very wide applicability and could be used to support learning about many different science principles.

Approximate costs of the experiences are given.

Interactive experience 01

Space Signpost

Helps to make space tangible and generates enthusiasm for a difficult topic.

Space Signpost has two components – a physical signpost and interactive software – that can be used independently or in combination. The software accurately models the dynamics of objects in space, from low orbit satellites to distant quasars. It needs just two pieces of information to locate objects and display them correctly – the time and coordinates of the Signpost's physical location.

Teachers say space is a difficult topic to teach and would like to encourage learning in a more investigative way. The value of the Space Signpost for school science is its clear connection with the world beyond the lab – one of the most important factors in making resources appealing to students.

The Signpost, with its software, has a dramatic effect on students' engagement with the subject. It can point in real time to any object in the universe and display detailed information about it via the integrated touch–screen. Its software was developed in collaboration with students and built on top of Celestia, the most sophisticated space simulation software available.

The main differences between this software and other astronomy programs are that it can be totally customised – and students don't require any training to use it. The Space Signpost provokes students to ask questions. It then offers them engaging and interactive ways to answer these questions for themselves. Its direct, real–time connection to space means students can engage with astronomy on their own terms, unmediated by experts.

Space Signpost could be applied in many different ways, using customised user interfaces and linked to customised multi–media resources. Most of this tailoring can be done by teachers themselves, requiring little technical knowledge. Routine maintenance on the physical Signpost should also be minimal. A desktop version of the Signpost is being developed to make it accessible to more users and more schools.

Space Signpost relates the vast scales of outer space to the particular space that students are occupying, transforming abstract ideas into concrete, embodied experiences. Distances displayed on the Signpost are site specific and, importantly, relate to the students' actual location.

The Space Signpost makes science concrete and immediate. It offers a variety of teacher and student–led ways to approach science, and in museums a version of it has been shown to generate enthusiasm among young people. It transforms science and astronomy from a series of facts to be learnt to a subject students can explore on their own terms.

Approximately £7,000 per unit

Interactive experience 02

Force Explorer

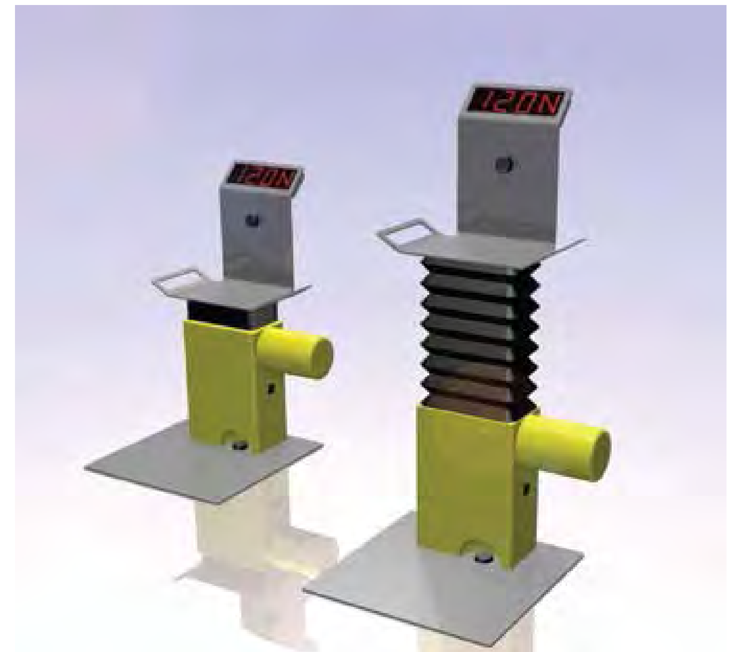
Allows students to use their own strength to understand weight and force.

Force Explorer is a rig that allows students to get a direct feel for weights and the strength of forces. They can compare masses and explore pulleys and mechanical forces, making comparisons like "If the Earth had a mass of 1kg, how much would the mass of Jupiter be on the same scale?" (Answer: 318kg.) They can also explore what it would feel like to pull an oxygen molecule apart in comparison to a water molecule.

The rig acts like a large mass, which students try to lift by pulling on a rope connected to a pulley. The end of the rope is connected through a series of gears to a 'stepper motor' (an electric motor with stepped gears that allow it to turn precisely). This can be configured to offer a range of resistances corresponding to a weight between 10N and 1,000N. Students pull this weight through a distance of 50cm to experience the work they do.

Force Explorer offers approaches to abstract topics based on student movement and actions. These 'kinaesthetic' experiences are much more intuitive and memorable for students than numerical relationships. For instance, it can be used to illustrate abstract ideas in ecology like the ratios of bio-mass in different parts of food-webs, e.g. "What does the mass of top predators feel like in comparison to the mass of primary herbivores?"

There are various options for installing the Force Explorer to make it accessible to students. It can be a permanent installation outside a building or in a 'contemplation zone' or 'science resource area' like those proposed in many of the Faraday designs. Alternatively, it can be stored and brought out only for specific lessons.



The Force Explorer gives teachers more ways to bring difficult topics to life for their students. It's a tool they can use to develop new approaches to teaching – by expanding their repertoire to include kinaesthetic methods.

Some students can be put off because science appears only to offer a cerebral way to engage with the world. Abstract concepts like force and mass can be alienating if they are only accessible numerically. The Force Explorer connects science to a wider range of experiences. By relating kinaesthetic experience to numerical magnitude, it can engage students and make equations easier to understand.

Approximately £10,000

Interactive experience 03

DIY Robot Lab

Encourages students to be creative and improvise through robotics.

A set of components for students to make robots from, stored in specially-designed mobile furniture which can be slotted together to save space or arranged in different ways to create activity zones within a larger space.

Storage units for the Robot lab can be nested to store away, and moved around to create ad hoc work areas.

Everyday electronic and electrical components, equipment and tools are stored in sliding drawers, displayed in moveable furniture. The components are carefully chosen so they can be combined together in thousands of different ways, creating an almost unlimited range of experiments and prototypes.

The drawers are colour-coded and divided by function, with sections for:

- components that supply power
- movements and mechanisms
- sensors
- control systems

Each section has information about the use of each type of component, to give students ideas. Completed robots can solve problems, measure processes, test theories or just allow students to have fun.

The furniture is shaped so units can be nested together. It can also be arranged to form small spaces in any part of the school – for group activities, free time club activities, or community activities out of school time.

DIY Robot Lab was inspired by pioneering scientists of the past – like Da Vinci or Leeuwenhoek (builder of the first microscope) – who worked with very limited materials and had to improvise. Students learn to adopt a scientific approach as they improve their robot designs – experimenting, testing, evaluating, adjusting and repeating the experiment.

The lab can support several areas of the science curriculum, including systems and feedback, optics, electronics, programming and mechanics.

The lab could also be used for cross-curricular projects such as art in science, and it supports many of the 'soft skills' identified as important by employers – such as problem solving, teamworking, curiosity and persistence.

Furniture units (inc. shelving, castor system, power, ICT, graphics and production) approximately £15,000 each. Components £5,000 to £10,000 per kit.

Interactive experience 04

Drop Zone

Makes gravity and acceleration memorable and fun.

The Drop Zone is a tall, vertical enclosure that allows objects to be dropped safely. Students can observe and measure how they fall using sensors and high speed cameras. The installation can be thought of as a giant support framework, which can be re-configured to carry out all sorts of activities. Students can build devices to send things up the tower as well as tracking objects falling or flying down it.

The tower consists of a 5m-tall steel frame, clad with clear acrylic panels, many of which can be opened to allow students to reach into the tower from surrounding stairways or platforms. The steel frame acts as an armature to support a series of mechanisms for launching, lifting or moving objects within the tower and a series of sensors to track and record those movements or events.

If necessary, strobes can be used with cameras to allow more detailed analysis, or water pipes can be lifted through the column to show atmospheric pressure.

It's very simple and intuitive – students climb the stairs leading to access platforms, and drop whatever object they choose through the enclosure. This allows them to test, develop, improve and re-test in a self-guided and open-ended way that's a great resource for students at all ability levels.

The Drop Zone gets students to look at how things move and the way energy transfers from one form to another. The most obvious experiments are based on basic physics principles:

- Gravity and acceleration due to gravity – Galileo's classic demonstration, where he dropped a musket ball and a cannon ball off the Tower of Pisa (allegedly).
- Trajectories – patterns of movement resulting from a constant acceleration (or deceleration) in one direction.
- Conservation of momentum – elastic and inelastic collisions, bouncing and stopping (reflecting and absorbing energy). Can we make an egg break the same way twice? How do different surfaces affect how objects and sound bounce back up the tower?
- Air resistance and aerodynamics – flying, or more accurately, controlled falling. This echoes pioneering work in aviation by George Cayley.
- Buoyancy and the density of gases – balloons, lighter than air and hot air can be inserted at the bottom of the Drop Zone and allowed to float to the top.

Indicative cost of structure, cladding and hatches: £25,000 – £40,000. Sensors and electronics £10,000 – £15,000.

Interactive experience 05

Knowledge Garden

Provides an engaging, real-life forum for experiments.

Knowledge Garden is a living recycling system which allows students to explore the natural world, ecology and biodiversity immediately and continuously. It consists of a constructed wetland that recycles water naturally, without harmful industrial reprocessing.

Water is channeled through a series of reeds and other plants, with different plant species and bacteria feeding off the impurities in the water and slowly making it cleaner.

As the water is progressively cleaned, each plant species gradually gives way to successor species that continue the process, until the water is clean enough to support tadpoles, water voles and dragonflies. The water can be used to irrigate playing fields, wash dishes and in showers. If it's then passed through a ceramic filter and under a UV light, it reaches a level of purity similar to the best bottled water sold today.

In this case, students help design and plant the garden – close to the male urinals in the school. Rather than pumping waste water from the toilets away for industrial reprocessing, it's used locally to support some of the rarest plant and beetle species in Britain and to reduce the school's water waste. A series of experiments is undertaken to demonstrate the progressive purification of the water and to help students understand natural habitats.

Students also support an ambitious attempt to make the school water neutral, in the sense that all water used on site is sourced locally. Rain landing on the roof or the car park also flows into a second constructed wetland and is used to irrigate the playing fields. Water at the bottom of the school is pumped back to the top, using a combination of wind technology and pumps fitted to the merry-go-rounds in an adjacent primary school. This water is then rendered as pure as mineral water and routed to drinking fountains.

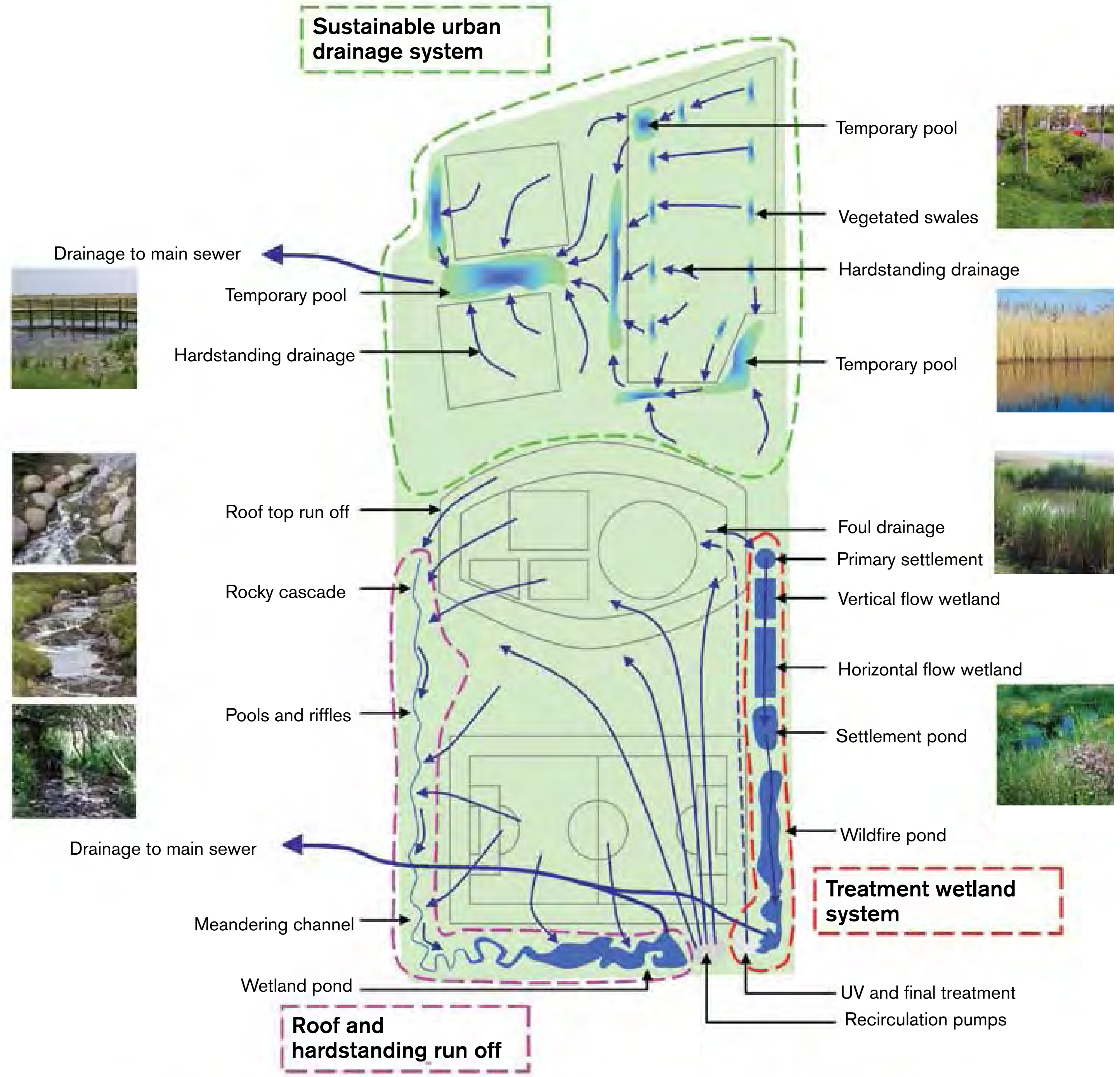
Knowledge Garden supports numerous experiments in natural sciences, including:

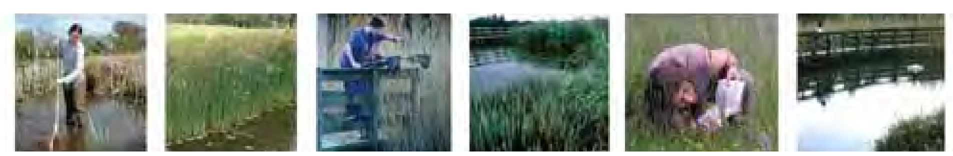
- biochemical oxygen demand
- reproduction studies (plant and animal)
- nitrification
- PH levels

It also provides a forum for aspects of history, geography, business studies, citizenship and mathematics. On top of this, students using Knowledge Garden will develop skills in long-term project management and collaborative learning. The site supports audio, visual and kinaesthetic learning.

Approximately £20,000

Knowledge Garden: Concept plan for integrated water management.





Interactive experience 06

The Matrix

Allows students to act out the movement of different molecules.

Rather like 'dance mats' used with games consoles, the Matrix is a roll-up neoprene mat with light-emitting diodes and pressure sensors embedded in it, connected to a PC to drive light patterns and detect how it's being touched. It's intended to help students understand solids, liquids and gases.

The Matrix consists of a series of 100 pressure sensitive pads, each containing 100 light-emitting diodes (LEDs) which can be individually programmed to form characters or to work in unison to create one large image or diagram.

The LEDs light up, showing how students should move around the mat, and the pads allow the PC to determine whether the student moved to the right pad. The original idea, which came from a workshop with the school, saw the Matrix light up the molecular composition of gases, where two or three pupils would dance across the map following the lights. Then more students would join in to mimic the slower, more compact movement of liquids, finally to be joined by the whole class in a tightly packed mass of molecules with little or no movement.

It's also possible to present options to students and allow them to choose the one they think is correct. Alternatively, by setting the controls differently, students can use their movement across the mat to control output from the LEDs. The design is intended for use outdoors (although it could also function indoors), sited for easy access – say in a courtyard close to the science facilities.

Students enjoy learning in a variety of different ways and each student is different. This tool allows staff to teach in an engaging, physical and memorable way that gets students out of their seats. As well as molecular structure, the Matrix can be programmed for studying atoms, the periodic table, or the solar system.

Using the Matrix in the landscape rather than in the classroom increases flexibility and means it could be used not just in science but in many other subjects too.

Approximately £25,000 including installation

The Matrix is ideal for kinaesthetic learning.

Interactive experience 07

How did that get there?

Stretches students' analytical and hypothesis-testing skills.

Specially designed 'pods' containing unusual artifacts serve as clues to explain an unusual phenomenon. The pods are lit from the inside and may contain screens, webcams or digital sound recorders.

Alternatively, a single object is 'discovered' in the school grounds, prompting a scientific investigation into how it might have arrived.

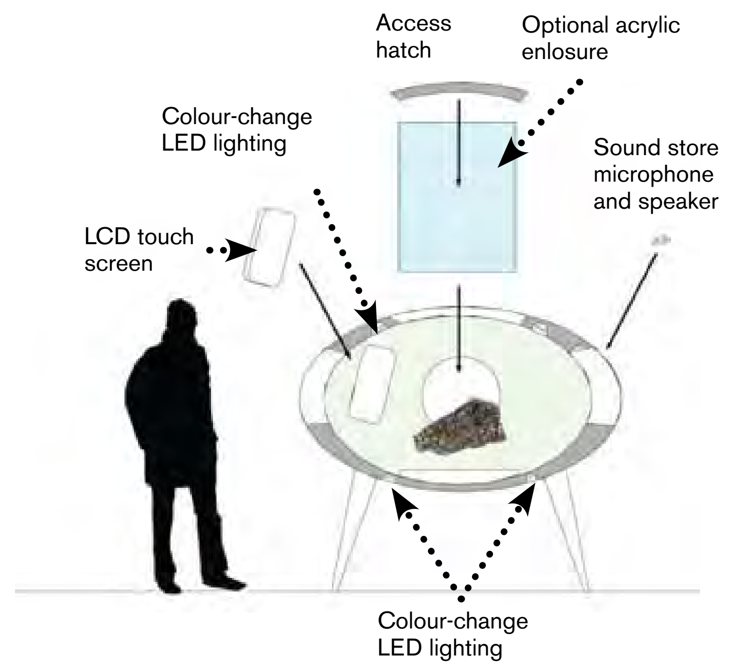
In the case of the pods, clues are left around the school grounds, building up to allow students to work out what's happened. The clues may be supplied on loan from local businesses, from museums as part of their outreach activities, or from other schools.

Students can record their hypotheses about what happened using surfaces of the pods that can be written on with chalk, or digital recorders, or LCD screens.

Various intriguing objects are placed around the school, containing a changing sequence of objects.

Weblinks may also be established so that student findings and clues from one school can be shared with other schools. These clues may even be merged with the pods, so information from School A can be displayed alongside a clue in School B.

For the single object (or a group of objects making up a scene) discovery, something strange and unexpected happens at the school – for example, a perfect cube appears in the playground without explanation. Students have to work together and figure out how the object arrived, using their own hypotheses.



In a variation on this theme, students are told that a Harrier jump jet will be landing in the school playground next week as the subject of 'How did that get there?' The students make sensors to detect its thrust levels and measure the displacement of sound waves, using these measurements as the basis of a research task to understand how Harriers achieve vertical take-off and landing.

How did that get there? may be applied to many different parts of the curriculum, but the real benefit is in allowing students to build thinking skills. They will learn about:

- developing hypotheses
- structuring research
- presenting and exchanging ideas

The tasks arising from these activities are also very well suited to individual learning journeys for students.

£5,000 to £10,000 per unit, depending on the extent of ICT.

Interactive experience 08

Digi-Posters

Provides a real-time link to top-rank international science.

A Digi-Poster is an innovative way to display student work, to link current science lessons to cutting edge global science, and to keep displays up to date automatically.

A Digi-Poster consists of two elements – a printed poster and an electronic screen. The poster is printed on paper with a hole cut in it so multimedia content can be displayed on a screen within it. Content for the screen can be added with a memory card or a network connection.

The screen displays content held on a specific internet address – for instance, the latest images returned by a space mission. Changing the poster involves hanging a new paper poster and directing the screen to a different internet address.

It's currently very difficult for students to engage with leading edge science initiatives like the Human Genome Project, the Large Hadron Collider and space missions such as Cassini-Huygens. Posters usually lack impact and immediacy. Digi-Posters can provide a live connection to real science and, more importantly, to the real world. They also give learners the background they need to make the live data personally meaningful.

The value of Digi-Posters comes from the combination of digital and printed content, enhancing the strengths of each medium. Printed material can display a far higher density of information than a screen, at much less cost. Unlike ordinary posters, Digi-Posters are always current, displaying the latest results and live images. But they go further than a screen by itself would, because they provide a context for the displayed results.

Digi-Posters can also make traditionally difficult topics easier to understand – when concepts like waves, electricity or radiation feature in class, teachers can ensure that appropriate Digi-Posters are available in the lab and around the school. These can reinforce the learning that goes on in the class itself by providing material that students can engage with on their own terms and in their own time. Digi-Posters can also give abstract topics a sense of relevance. Unlike textbooks or web-resources, students don't have to 'buy in' to these resources – they're always present.

Approximately £2,500

Interactive experience 09

Aerodynamic Investigation Resource (AIR)

Allows students to take an active part in aeroplane design.

AIR is a computer-based simulation of aerodynamics, to design and test aeroplanes designed by students in a wind tunnel. It also includes a physical set of plane parts that students can use to build real-world versions of the planes they design on computer.

It will operate on two levels – younger students can choose 'Test and Make', where a range of aircraft components on screen can be assembled and tested in the wind tunnel and flight projections and trajectories calculated. These can then be recreated using the real plane parts, which consist of six types of body, wing, tail and nose shapes. The finished plane can be taken outside and tested.

Older students can choose 'Test and Build', which allows them to manipulate the exact shape of each component – width, height, breadth and shape – using sliding bars. These can be tested and plans printed for each component for the student to make in design and technology, and then test in the real world.

Students explore aerodynamics, following simple principles of experimentation. They can make numerous minor adjustments to their virtual planes and test them after each change to see what effect they have. Students are given flight trajectories, which they explore in more detail by reviewing the calculations that lay behind them. This means they form clear links in their minds between the physics of aerodynamics and maths.

Because the experience is ICT based, it's easy for students to share designs and flight trajectories with other schools, and schools can run competitions to test and build the best design.

AIR is particularly well suited to hypothesis testing. For example, a student believes that in-flight stability is linked to the size of the wings. Using the simulation, he or she can very quickly test three or four different wing sizes to see if their hypothesis is correct.

Naturally, it's specifically designed for learning and teaching about aerodynamics, but it could also be useful for aspects of mathematics and possibly biology – the virtual wind tunnel could be used to study bird and insect flight.

Approximately £8,000 including software

AIR's computer interface is very visual, making it easier for students to pick up.

Section 06

Learning from overseas

As part of the research phase of the project, the three Faraday teams went on study missions to see what they could learn from different parts of the world. As well as the UK, they visited the US, Australia and Denmark looking for unusual approaches to learning and teaching.

The lessons they learned fed into their design work for the Faraday Schools. This section pulls out some of the most influential examples that the teams uncovered.

This school has a uniquely flexible system for organising students that's part architectural and part administrative. The 'house' system puts students into year groups, each with an open plan 'house' space. This is arranged into 10 'pods', each with personal desks for 10 students. In the middle of the house space are tables and chairs that can be rearranged as necessary.

The personalised, open plan space allows learning and teaching to switch easily from individual study to collaborative teamwork to whole-class lectures and discussions. The system means students own the space and have a sense of community, which supports their engagement with learning. There are no corridors but long sightlines both within and outside the building. In contrast to other schools where open plan teaching has been tried, there was no attempt to demarcate the space or create partitions.

The school makes creative use of its extensive grounds, including an outdoor classroom that overlooks a lake and has a timber roof to keep off the sun and rain, with excellent views out onto the school grounds. One particularly successful feature of this classroom is the way it links

This outdoor classroom has fine views all year around, and permits real-world science observation and monitoring.

to the main school buildings. There's a strong visual link between the outdoor classroom and inside the main buildings, including the library.

The school maintains relationships with partners around the world, including field centres in Scotland and Hawaii. The sense of connection is immediately obvious to visitors and is reinforced in staff and students by displays presenting the work carried out at these centres.

With a few exceptions, exhibits in science museums don't provide a good starting point for thinking about spaces for science in schools.

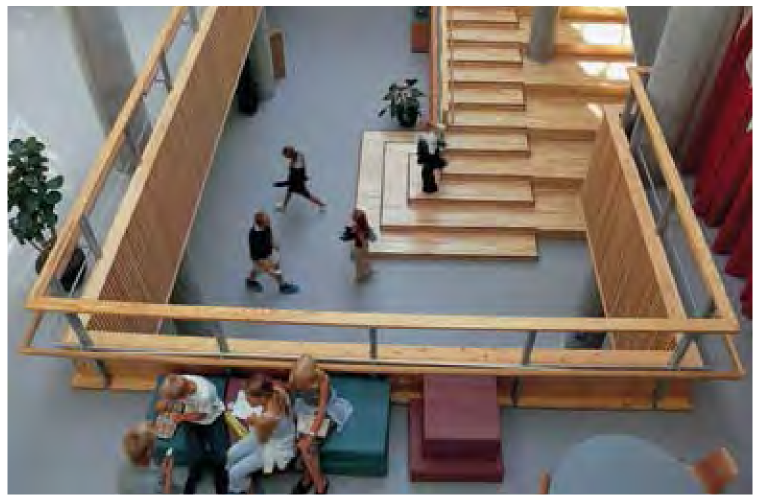
The role of a science museum and its relationship with its users is wholly different from the role of a school. In general, science museum exhibits need to communicate very quickly but don't need to sustain interest in the visitor for very long. They are usually highly focused, with only a single way of interacting with them. Resources and spaces in schools are different. They have to sustain interest over a whole school career and allow teachers and learners to address their own questions. What schools can learn from science museums is how to create links to assets in the school grounds and beyond – and how to make connections with live science in real time.

Several exhibits in the Minnesota Science Museum are linked visually to the Mississippi river, which flows past the window. The link helps visitors engage with the exhibits and increases the museum's impact. In this way, they offer a model for schools, because in schools too there is scope for adding value to science by making the links obvious. For instance, as visitors pilot a virtual barge (one popular exhibit), they can watch real barges chugging along the river. Without the visual link, the exhibit would be just a simple

Exhibits relating to the neighbouring Mississippi river help to link the real and virtual worlds.

video game. But linking the real and the virtual makes the exhibit genuinely interactive and engaging and provides a new perspective on fluid dynamics and hydrology.

An art installation in the museum links real-time earthquake monitors to musical sounds. The installation has a powerful impact on visitors by connecting the museum to the rest of the planet. Unlike other science museums, the Minnesota Science Museum locates its visitors in the world. By making the relationships visible, and even audible, it adds another dimension to the learning experience.



Hellerup Skole.

Hellerup Skole in Denmark was chosen as a school to study because it has the most radical known model of personalised learning anywhere in the world. The physical facilities and school management are both designed around the needs of learners. The premise is that, since every student learns and thinks differently, each should have the opportunity to be creative and discover for themselves how they prefer to learn.

The school is divided into three ‘home areas’, each with facilities to support all learning activities – theory areas, places for group work, places for individual work, wet and dry areas, places for presentations, areas for reading and areas for PC work, places for cooking and places for experiments. Each home area caters for mixed age groups – one is 6 to 9, the second 9 to 12, and the third 12 to 15.

Nearly all the facilities are open plan – even some science facilities, like some experiment space and the area for wet work.

The main learning points from Hellerup were:

- The design of science facilities needs to be based on a clear understanding of the learning and teaching model.
- Teaching staff have to be involved in moving to a different model of learning and teaching, which typically requires on-site training.
- Facilities continue to evolve once the school begins to be used – at Hellerup an open plan staircase that doubles as an informal presentation area was enclosed to make it quieter.

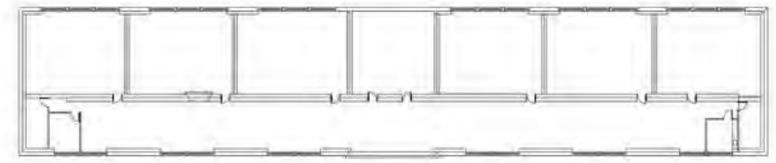
The Danish University of Education has put a lot of effort into building scientific simulations to be used by schools for teaching. As an example, they have a simulation based around forensic investigation. Using the internet, students access progressively more information about a murder in a locker room. There are videos of witnesses and suspects, photographs, fingerprints and DNA samples, along with explanations from real forensic scientists.

Students work in teams to unravel the mystery in a week, performing a range of practical experiments and online research to investigate the murder. One of the main learning points from this was not only the success of engaging students in an exciting real life situation, but also the benefits of providing a physical setting to support the work. The learning lab showed how to turn a classroom into ‘research offices’ for students – flexible furniture and physical divisions of space meant that students could break into smaller groups successfully.

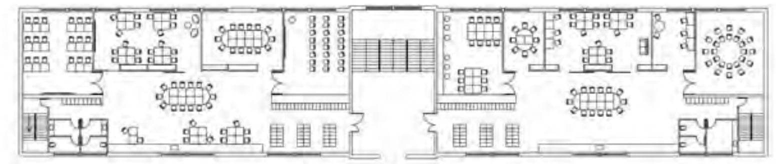
This school was designed by the same team as Hellerup, but it was a refurbishment project that turned a very traditional layout into something much more flexible and better suited to personalised learning – a very economical way to meet similar objectives.

Before the refurbishment, there were six classrooms for 25-30 students along a corridor with a small atrium in the middle. The refurbishment made much better use of the corridor, with a range of different sized interlinked learning spaces that can be shut off or opened out according to learning objectives.

This project illustrated that even small changes to the layout of existing buildings can dramatically improve the potential for innovation in teaching. It also showed that multiple entrances and exits to rooms mean circulation routes can change and corridors may not be necessary.

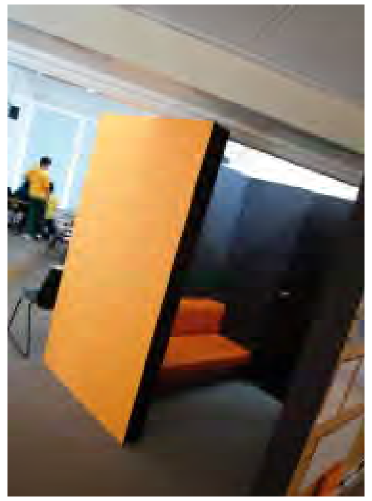


‘Before’ floor plan showing six classrooms.



‘After’ floor plan showing two home areas.

The Danish government set up the Mindlab as a facility for planning public policy, so policy makers, the private sector and academics can collaborate together. It has several unusual settings, the most relevant for Project Faraday being the ‘mind’ – a large egg-like structure with no edges or corners, where you can write on the walls. It allows freedom of ideas and continuity of writing, so a group of people can work together brainstorming without outside distractions.



Waroona Park showed what you can achieve even with very young students in a primary school.

This school for 350 has students from very socially underprivileged homes. It was refurbished in 2005 in a project that included three new spaces, two of which offered pointers for Project Faraday. The first, the Da Vinci centre, brings together the school library, small spaces for personal reflection, a presentation area and large spaces for group activities. There's also a rich media space, with access to a range of technologies, supported by a filming area, with 'green screen' technology, which allows different backgrounds to be projected behind what's being filmed. The centre enables even very young students to make choices about how they want to learn.

The second new space, the 'prep unit', has large and small spaces and areas the youngest students can rearrange for themselves. It includes a reading loft and opportunities for integrating technologies, including iPods.

This is a purpose-built school to explore new ways of learning and teaching in science. It has only a small number of classrooms and most learning takes place in large open plan 'learning commons'. There are nine of these in total, accommodating anything from 30 to 120 students.

The learning commons are meant for theory and investigation, with data projectors that project directly on two screens and so provide focal points for teacher-directed sessions.

Learning 'studios' are more practical, intended for students to make sense of material presented in the learning commons. They are equipped differently – one's a wet lab for biology and chemistry, another focuses on 'personal performance' (for activities connected to the human body), while another is equipped for robotics and physics.

The school has no corridors, and staff areas are open to students, which encourages them to ask staff for help when they need it. Spaces are largely self-managed by students using a booking system, and they have a strong feeling of ownership over the space.

Most learning at ASMS takes place in open plan 'learning commons'.

VSSEC recreates what it's like to visit Mars.

VSSEC is the latest of three specialist centres set up by the local authorities in Victoria to promote excellence and innovation in science teaching. Its role is to provide authentic scenarios for space science.

From the moment you enter through automatic 'airlock' doors, the facilities create awe and wonder. The main lobby is an amazing room that quite literally reaches up to the stars. Most learning scenarios start in a lecture theatre for 100 students, which leads into either 'mission control' or the Mars simulation room.

All simulations are coordinated from mission control, which re-creates a NASA-type operations control room. This resource connects students to other members of their team, involved in fieldwork 'in space'. They have a video link and Bluetooth audio devices allowing them to monitor and direct missions. The simulations serve not only to hone students' science knowledge, but also to improve communication and leadership skills.

The Mars simulation room recreates a small crater on the surface of the planet. Before they go in, students are kitted out with replica space suits, including breathing apparatus, helmet, 'heavy gloves' and communications devices. Students go through a second airlock, entering an authentic Martian environment where they collect data and samples for analysis on site and, later, in the research standard lab elsewhere in the centre. The 'room' is an inflatable dome back-lit with effects to heighten the experience. These activities help improve students' problem-solving, teamwork and decision-making skills.

On the ground floor of this school's science department are two open plan classrooms of 56m^2 sharing access to a single practical space of 90m^2, also open plan.

The practical areas are booked through lab managers and can accommodate 50 students. The open plan practical and writing areas have proved their ability to allow teachers to learn from each other and to cross-fertilise ideas. However, there are some accoustic issues to resolve – teachers prefer the enclosed first floor spaces for some activities, such as writing.

Rostrevor also had some negative lessons. There's a new 'science discovery centre', which aims at flexibility and personalised learning, and leans heavily on ICT. But the students weren't involved in its design – and they don't feel they own it. What's more, there are restrictions on where students are allowed to go, and as a result the centre is currently under used, with students preferring parts of the school where they can roam freely.

More information

Key points from Project Faraday – a reminder of the key points that emerged from the process of developing the Project Faraday designs.

Self-assessment checklists – for people involved in improving school science facilities, some of the important practical points that Faraday teams had to consider.

Cost commentary – provides some general advice on the cost of science facilities and explains some of the extra costs associated with the prototype projects.

Contacts and references – organisations that can advise on developing science facilities, and publications about government policy, how to design science facilities, and how to make the most of technology in science learning.

- It's better to develop design solutions in parallel with the school's current and proposed learning model.
- A variety of settings – indoors and outdoors – can support inspirational learning and teaching.
- The whole campus – building and grounds – can provide a rich resource for creative science learning.
- The most successful design outcomes result from all users – science staff, students, designers, and other science partners – being involved at every stage of the development process.
- Staff and students need support through transition and change – both changes to the teaching model and the physical accommodation.
- It's a good idea to develop the technology infrastructure and ICT network as an integral part of the design process, ensuring that peripherals like data-loggers are borne in mind along with the rest of the system.
- Designs need to provide for both current and future learning and teaching needs.
- Interactive 'experiences' can help students grasp difficult scientific concepts.
- The best designs facilitate real and virtual partnerships – with scientific establishments, other schools, parents, and others – to enhance learning and teaching.
- An holistic approach to science, with shared ownership of space and an integrated approach to teaching, improves opportunities for all.

The checklists below show practical design points that should be borne in mind in any science building project. With thanks to CLEAPSS and others involved in Project Faraday.

Health and safety	Considered for this project (/N)
• Adequate provision for pupils to store their coats and bags if they are to be brought into laboratories.	
• Sufficient storage for large scale items (e.g. physics equipment), as well as small scale (e.g. glassware).	
• Lockable doors for all laboratory and prep rooms, which will be locked when not staffed.	
• Emergency shut-offs for gas, water and electricity (Various methods are suitable – they should be easily accessed by the teacher but not susceptible to interference from pupils.)	
• One large sink with hot and cold water in each laboratory for pupils to wash their hands after practical activities.	
• One eye-wash station in each laboratory, which must be sited to be readily accessible.	
• Enough fume cupboards for half the laboratory. (Mobile fume cupboards are adequate for some activities but not A-level chemistry. Prep rooms should be fitted with a fixed fume cupboard for technicians' use.)	
• Robust, good quality storage for books and CD-ROMs in all teaching rooms. (This will go a long way towards supporting the day-to-day housekeeping needed to keep rooms smart and organised.)	
• Unobstructed lines of sight to all students for supervision by qualified staff, including while students move between areas. (Serviced practical areas count as 'danger areas' under Management of Health and Safety at Work Regulations, so they need supervision from suitably qualified staff.)	
• •Adequate bulk storage for chemicals. (Refer to CLEAPSS advice in the guide L14, Designing and planning laboratories, and, for CLEAPSS members, in Chapter 7 of the CLEAPSS handbook.)	
Access and acoustics	
• Design caters for students with disabilities, which may include providing variable height practical tables positioned close to mains services such as gas, water and electricity, and suitable ICT equipment.	
• Every room allows free movement of at least one student in a wheelchair. Other modifications also considered. Not all laboratories may need to be fully accessible, but the science department should indicate which ones are.	
• Acoustics are critical and particular care needs to be taken with open plan areas or where moveable walls are used.	

The six renewal Faraday schools are prototypes, testing out a number of new ideas to inform and inspire other projects. As a result they cost more than traditional science accommodation, particularly the fittings and furniture. In the future, when more schools embrace the Faraday principles of design, it's expected that the costs will fall.

Other schools wanting to apply the Faraday principles will have to manage the budgets available and think about affordability in their own circumstances.

As demonstration projects, the Faraday schools will share their facilities with other schools and the wider community. Extra spaces, such as lecture theatres, will be used not solely for science but for the whole school.

All the Faraday schools are designed for sustainability and many of the features – like sedum roofs or renewable energy sources – can be used in science learning and teaching. But sustainable design is not unique to Project Faraday.

As with any part of school design, it's essential to consider the design implications of the proposed function of a space at an early stage to avoid additional costs later in the project. This is especially true of service infrastructure and acoustics in open plan areas.

Each Faraday school is unique and addresses issues and problems in its own way. What's evolved for one school may not necessarily work for another school. But there are some common themes relating to costs:

Acoustically rated folding partitions are provided in some of the Faraday schemes. These allow spaces to be readily manipulated to create larger areas for group activities. Partitions can add to the project cost, though, and a balance has to be struck between their cost and the flexibility they provide.

Many of the Faraday schools have more technology to enhance learning than other schools (especially ICT and display screens). There's a corresponding increase in the services requirements, especially power and lighting, and this inevitably increases costs.

Many of the Faraday teams explored new kinds of furniture to increase flexibility and facilitate new ways of learning. This purpose-built furniture, including mobile benches, is currently more expensive than traditional school laboratory furniture. Over time, however, with greater numbers being ordered, costs should become more comparable with standard furniture. Schools need to take into account the maintenance costs of bespoke furniture.

The Project Faraday designers were very imaginative in their treatment of external spaces for science. Creating external teaching spaces using the natural environment not only brings educational benefits, but this can also represent good value for money. A great deal can be achieved with limited funding.

Within a project there may be an opportunity to carry out part of the fitting-out works at a later date – either because of financial restraints or to give students the chance to construct a fitting as part of an ongoing school project. For example, the creativity pod at Abraham Guest High School could be provided at a later date and even constructed in-house as part of a major design and technology project.

The extra over-costs of the six 'renewal' school designs are £166 – £583/m^2 of the gross internal floor area, with most of them in the range £166 – £266/m^2. This is the additional cost over and above that of traditional science accommodation.

Notes: The cost base date is August 2007 and includes contingencies, fees and preliminaries. There is no allowance for inflation or VAT. The costs are approximate and are intended for guidance purposes only.

The• **Association for Science Education (ASE)** promotes excellence in science learning and teaching.
It's an authoritative forum for science teachers to express their views. www.ase.org.uk

Becta provides functional and technical specifications for new ICT equipment and services. Further support is available from engage@becta.org.uk or www.becta.org.uk

CLEAPSS, the advisory service for science and technology teaching in schools, has publications available in most secondary schools. It can also help people involved in developing science facilities by answering telephone enquiries. www.cleapss.org.uk

CABE, the Commission for Architecture and the Built Environment, offers a design review service to assess the quality of design proposals, and publications about school design. www.cabe.org.uk

DCSF, School Science: www.teachernet.gov.uk/schoolscience

The Institute of Physics is devoted to increasing the understanding and application of physics. www.iop.org

Learning through Landscapes helps schools make the most of their grounds and outdoor spaces. www.ltl.org.uk

National College for School Leasdership works to improve children's lives by growing and supporting school leaders. www.ncsl.org.uk

Partnerships for Schools is responsible for delivering the Government's secondary school renewal programme. www.p4s.org.uk

The Royal Institution of Great Britain has been working for 200 years to communicate science to the general public. Michael Faraday himself based his work there. www.rigb.org

The Royal Society of Chemistry is the largest organisation in Europe for advancing chemical science. www.rsc.org

Science Learning Centres provide continuing professional development for everyone involved in science learning. www.sciencelearningcentres.org.uk

The• **Specialist Schools and Academies Trust** strives to give more young people access to a good secondary education by building networks, sharing practice and supporting schools. www.specialistschools.org.uk

The Wellcome Trust is the world's largest medical research charity funding research into human and animal health. www.wellcome.ac.uk

Each of the three Faraday teams produced these documents, which are saved on the DVD accompanying this book:

- Literature reviews
- Overseas visits
- A3 brochures
- Virtual reality fly-throughs of their designs.

There is also more information about the interactive experiences included in this book, and others, on the Teachernet website under Project Faraday: www.teachernet.gov.uk

Roberts G (2002) SET for Success ('The Roberts Review'), HM Treasury, London – a review of the supply of science and engineering skills in the UK, commissioned as part of the Government's productivity and innovation strategy

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Gilbert C et al (2006) 2020 Vision: Report of the Teaching and Learning in 2020 Review Group, London: DFES – a vision for delivering personalised learning for 5-16 year olds

ASE (2004) Topics in Safety, ASE, Hatfield

ASE (2004) Lab designs for teaching and learning, ASE, Hatfield

ASE (2006) Safeguards in the School Laboratory, ASE, Hatfield

all available from www.ase.org.uk

The ASE's School Science Review also has regular articles on teaching science, practical science work and teaching science outdoors.

Braund M. & Reiss M J (Eds) (2004) Learning Science Outside the Classroom, RoutledgeFalmer, London

CLEAPSS (2000) Guide L14: Designing and Planning Laboratories, CLEAPSS, Uxbridge – available on the CLEAPSS website

DfES (1999, revised 2004) Building Bulletin 80: Science Accommodation in Secondary Schools, DfES, London – available on ASE and Teachernet websites – www.teachernet.gov.uk

Becta (2006) Thin Client Technology in Schools: A summary of research findings, Coventry: Becta

Becta (2006) Safeguarding Children Online: A guide for LAs and Local Safeguarding Children Boards, Coventry: Becta

Becta (2007) Signposts to Safety: Teaching e-safety at Key Stages 3 and 4, Coventry: Becta

Becta (2007) E-Safety: Developing whole-school policies to support effective practice, Coventry: Becta

Bryant et al (2007) Emerging technologies for learning (Volume 2), Coventry: Becta – includes papers on ubiquitous computing, and digital literacies

Stead G et al (2007) Emerging technologies for learning (Volume 1), Coventry: Becta – includes a paper on mobile technologies

all available from www.becta.org.uk

Futurelab – Innovation in education, see www.futurelab.org.uk

Futurelab – Enquiring Minds project www.enquiringminds.org.uk

STEMNET – www.stemnet.org.uk (information about After School Clubs and Science and Engineering Ambassadors Scheme (SEAs)