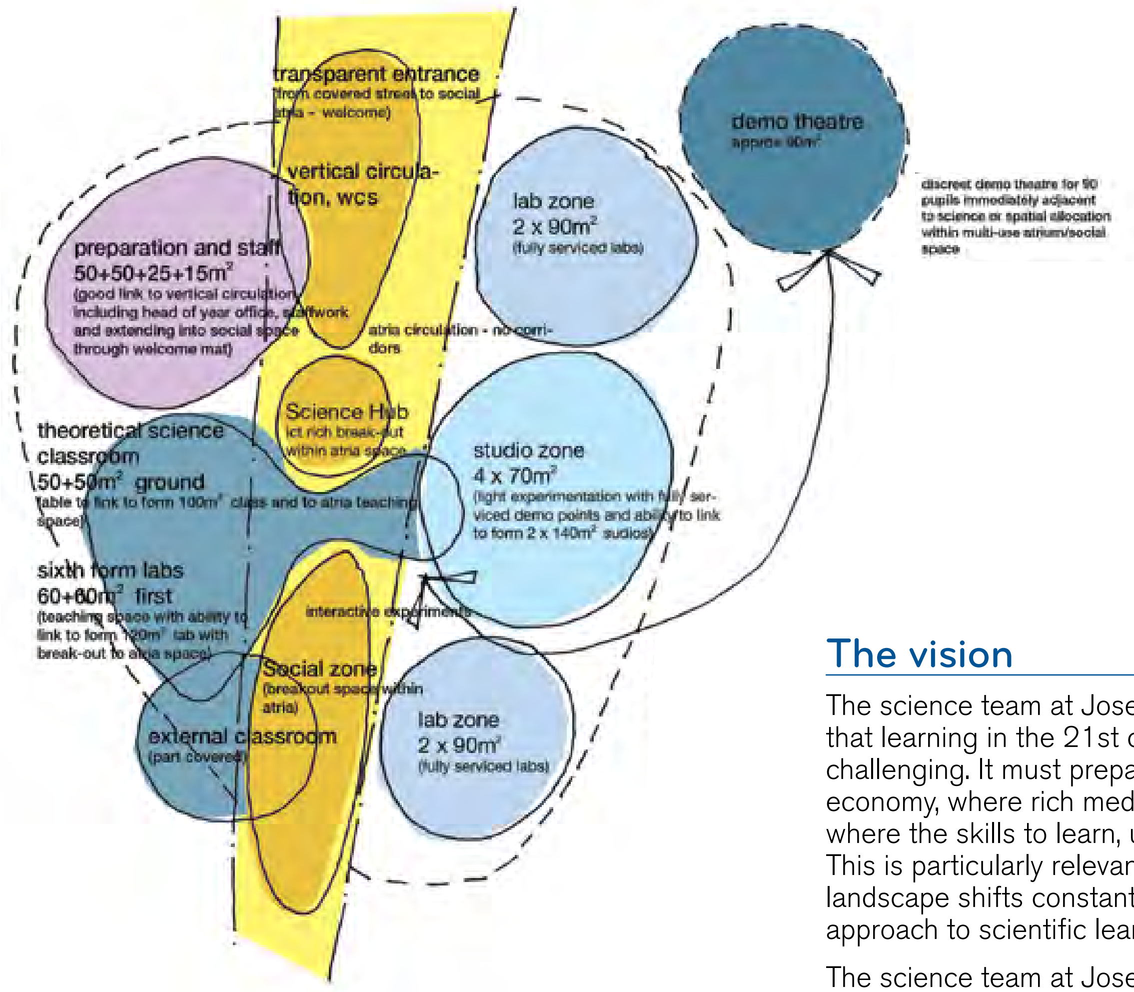
Renewals case study 04

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.

Number of students 1320
Local authority City of York Council
Age range 11-18
Project Faraday coordinator White Design Associates
School's design advisor 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.



Context

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 vision

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

Design rationale

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:

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

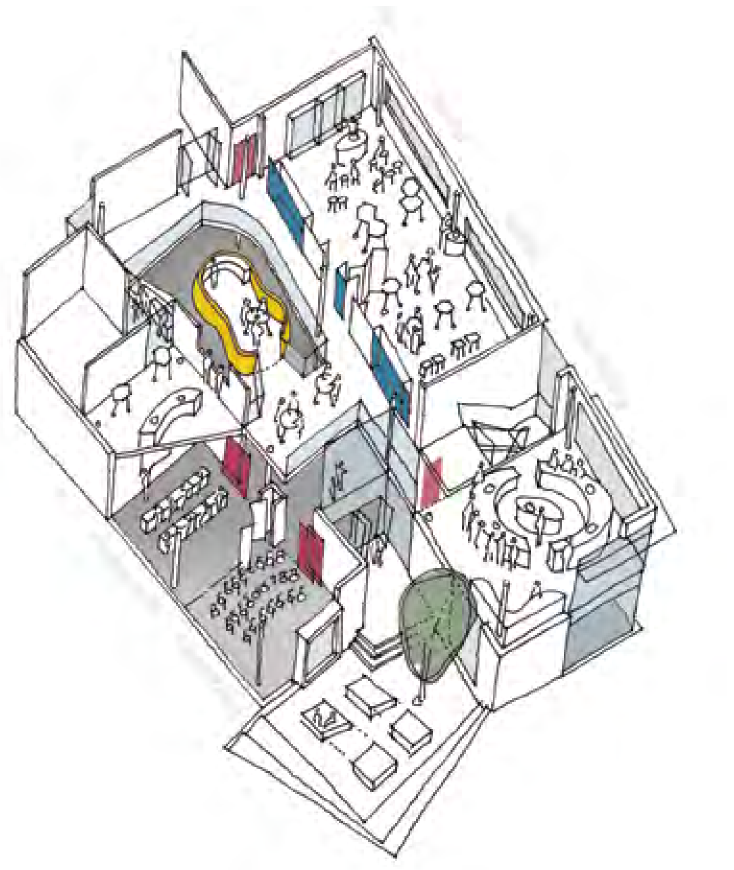
Here, students can celebrate their achievement and present their learning to peers and others. The space will build capacity for working in new ways – it must enable three classes to group together, and be reconfigurable so the flat floor space can be used too. It's also planned that staff will lead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



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.

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.

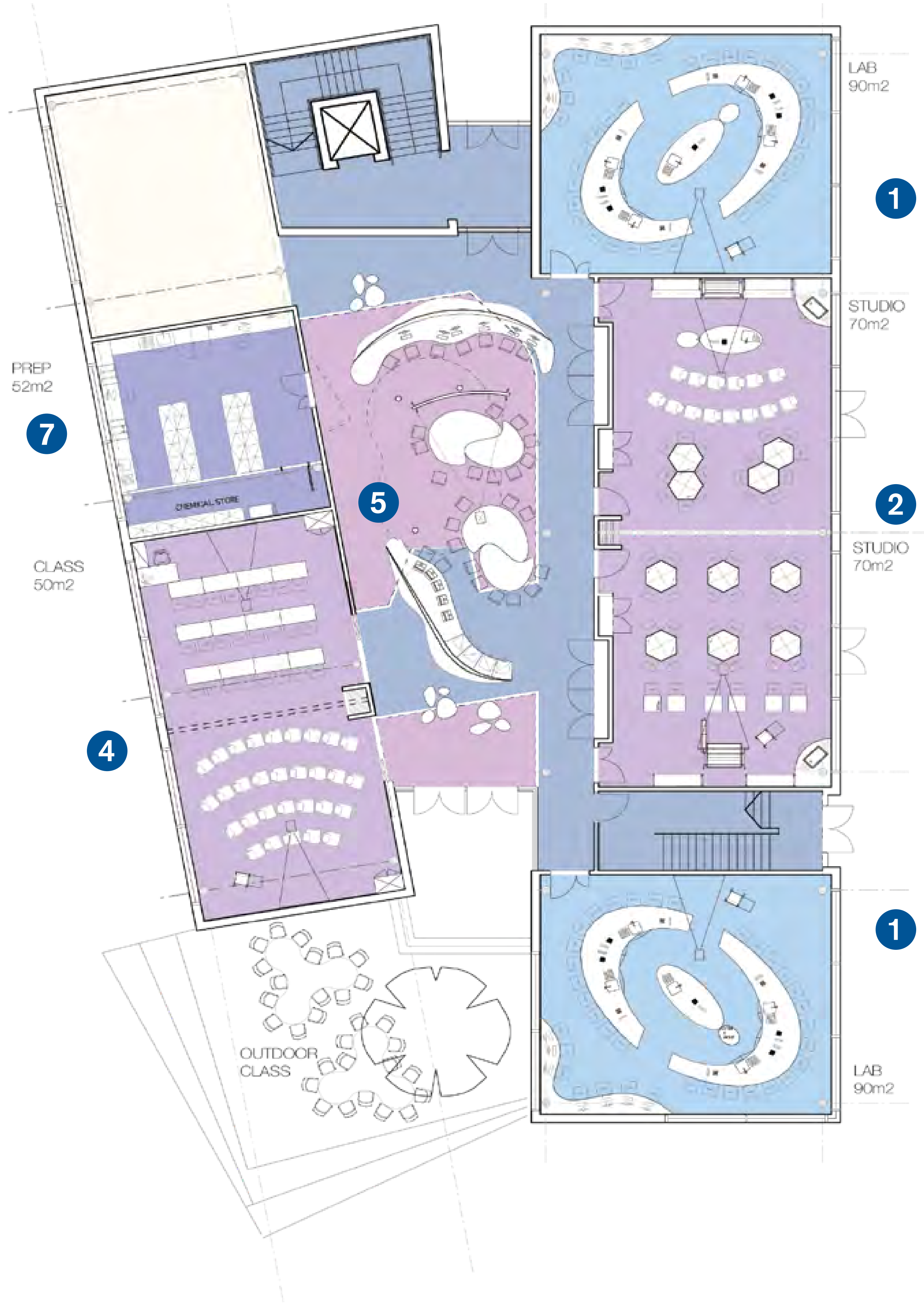
Concept plan showing key features of the design

The design

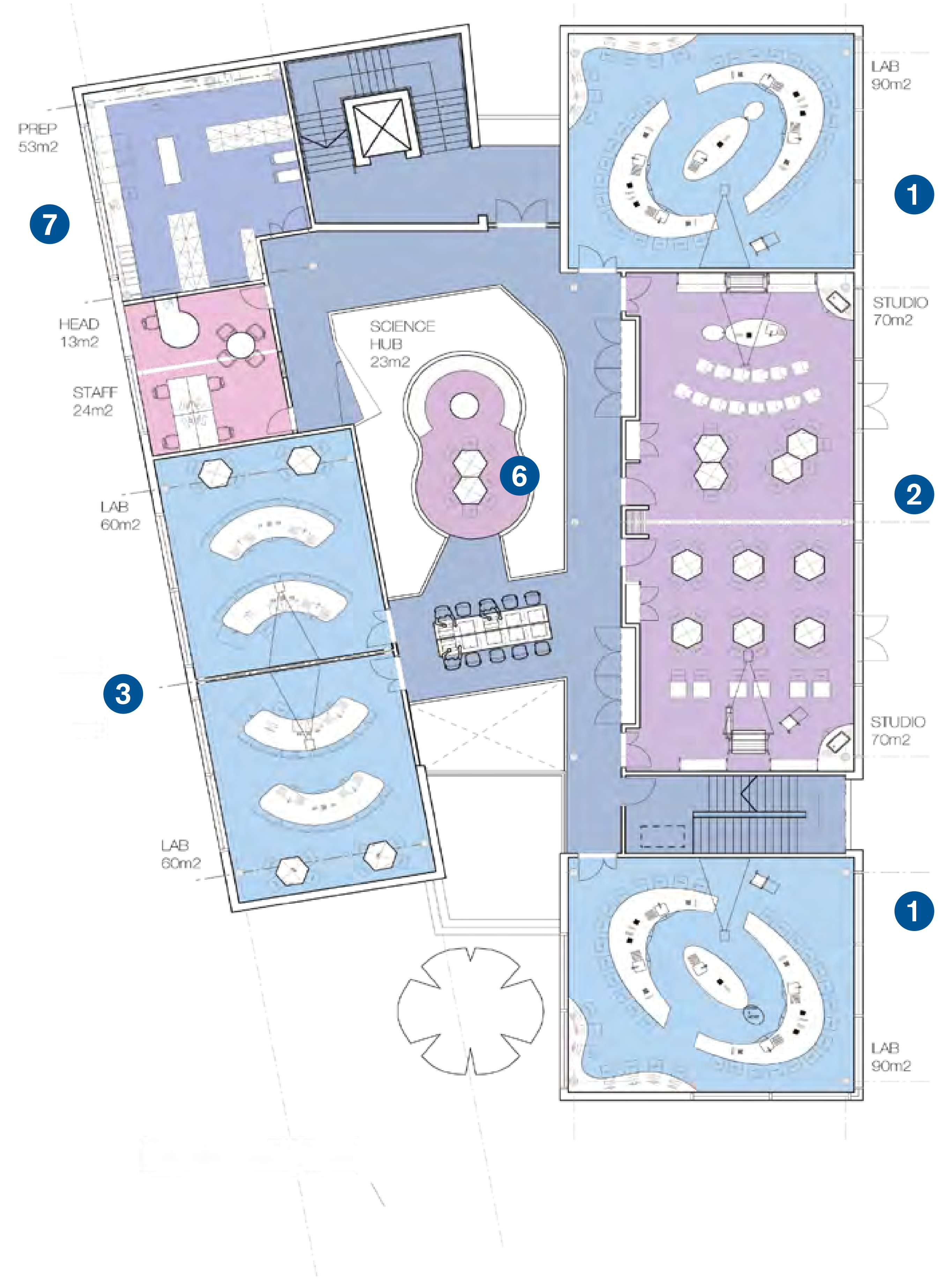
Students enter Joseph Rowntree's science accommodation from the main school at one end of a top-lit atrium, next to the main staircase. The opposite end of the atrium extends visually into the landscape by way of a highly glazed wall, specimen tree and external classroom. The design extends over two 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.

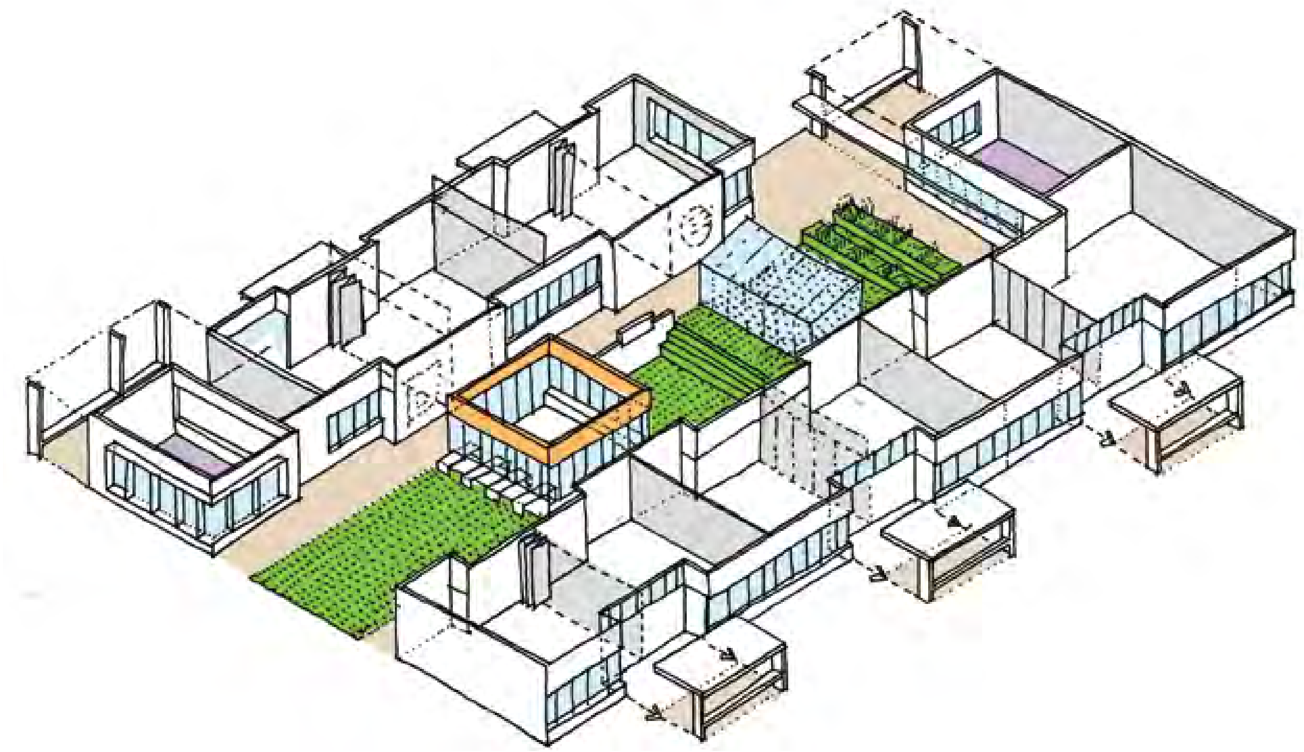
Renewals case study 05

Estover Community College

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

Number of students 1200
Local authority Plymouth City Council
Age range 11-19, adult community programme
Project Faraday coordinator GovEd Communications
School's architect 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.

Context

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.

The vision

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

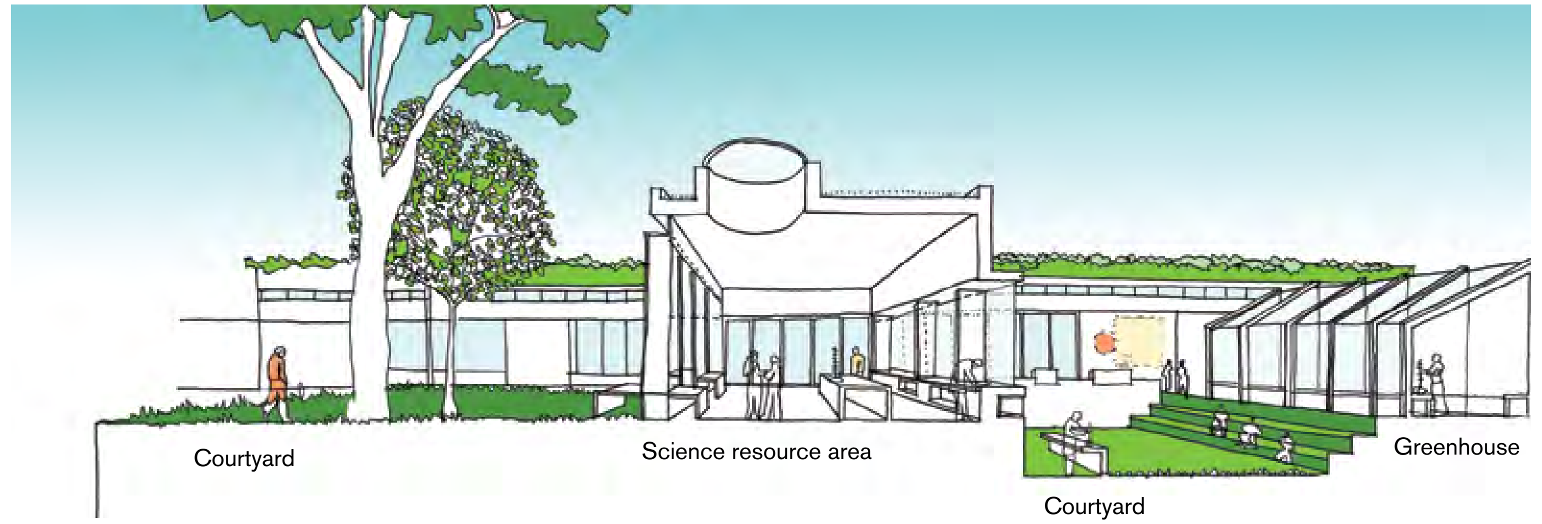
The school's philosophy of science learning and teaching is based on problem solving, experiential learning and skills acquisition, partly because staff identify content-driven science teaching as a major cause of student dissatisfaction with science lessons.

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.

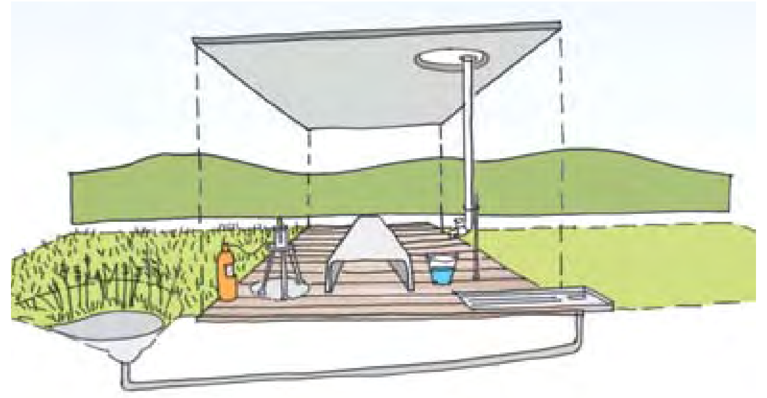
Design rationale

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.



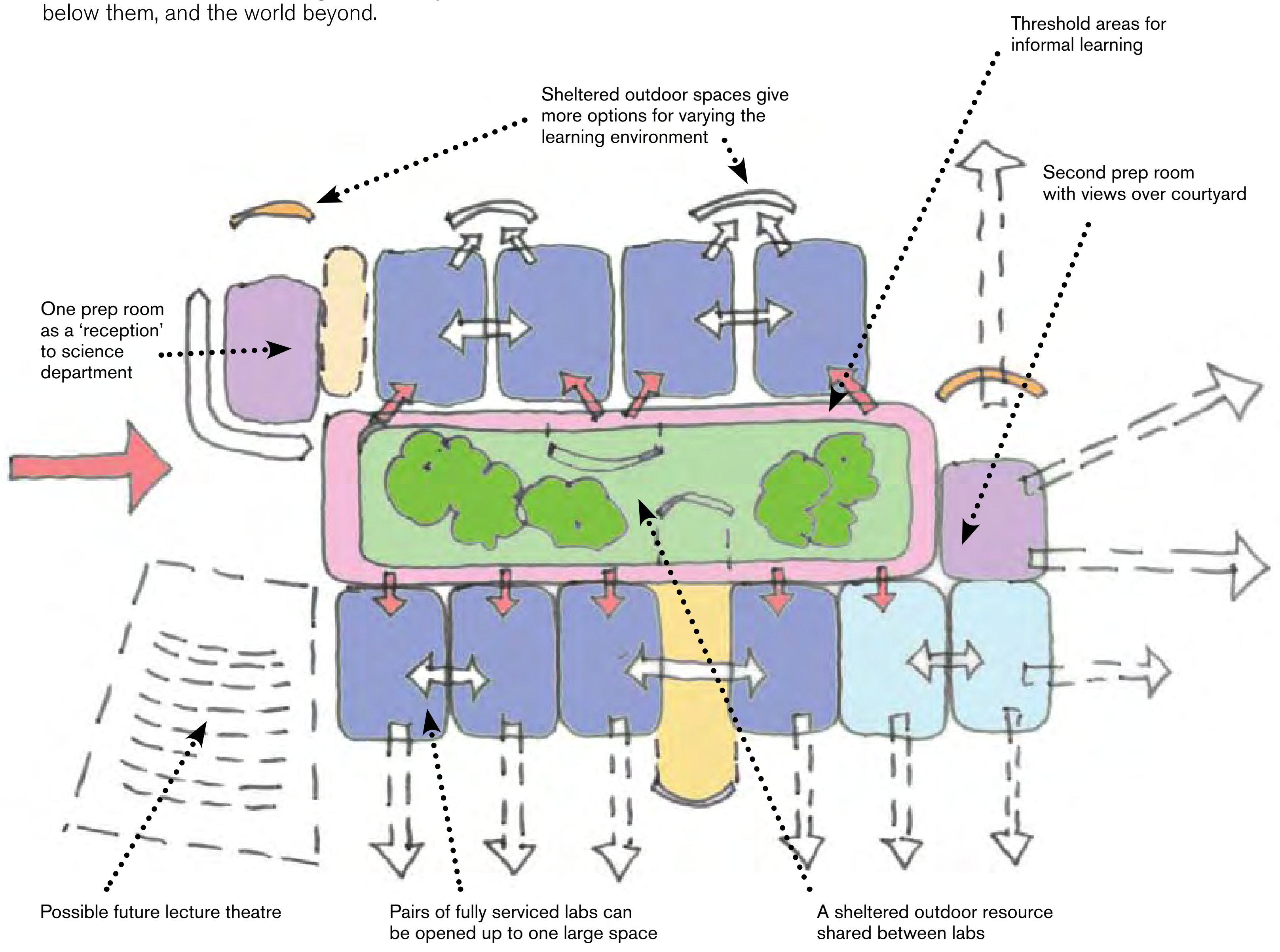
The designs

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.

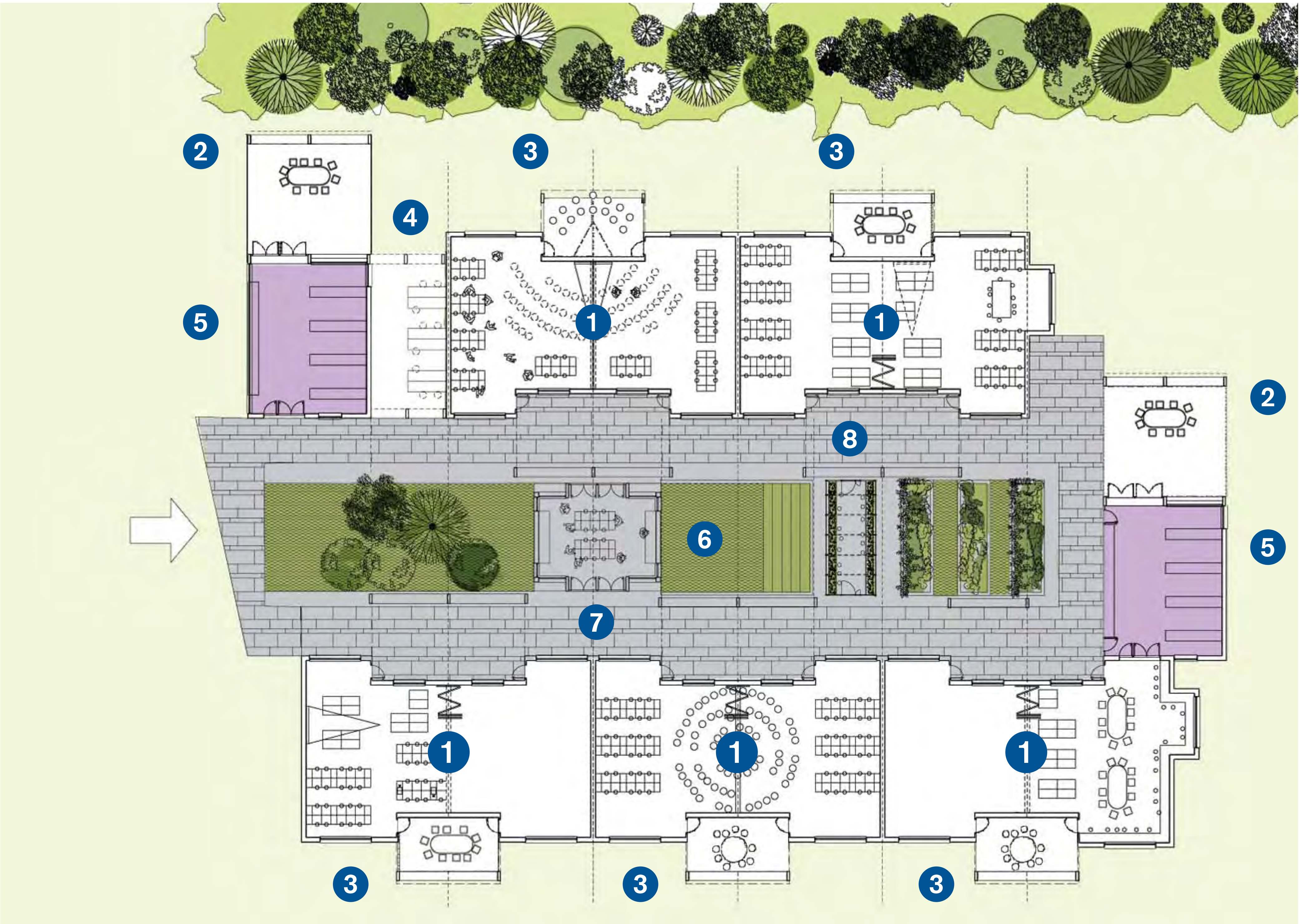
The most significant departure from the conventions for science departments is providing a place for in-house science outreach – in the form of a science discovery centre, placed within the science courtyard. It's a resource centre, taking the place of a laboratory, in which ongoing science experiments 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."
>
> **Student, Estover School**



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.

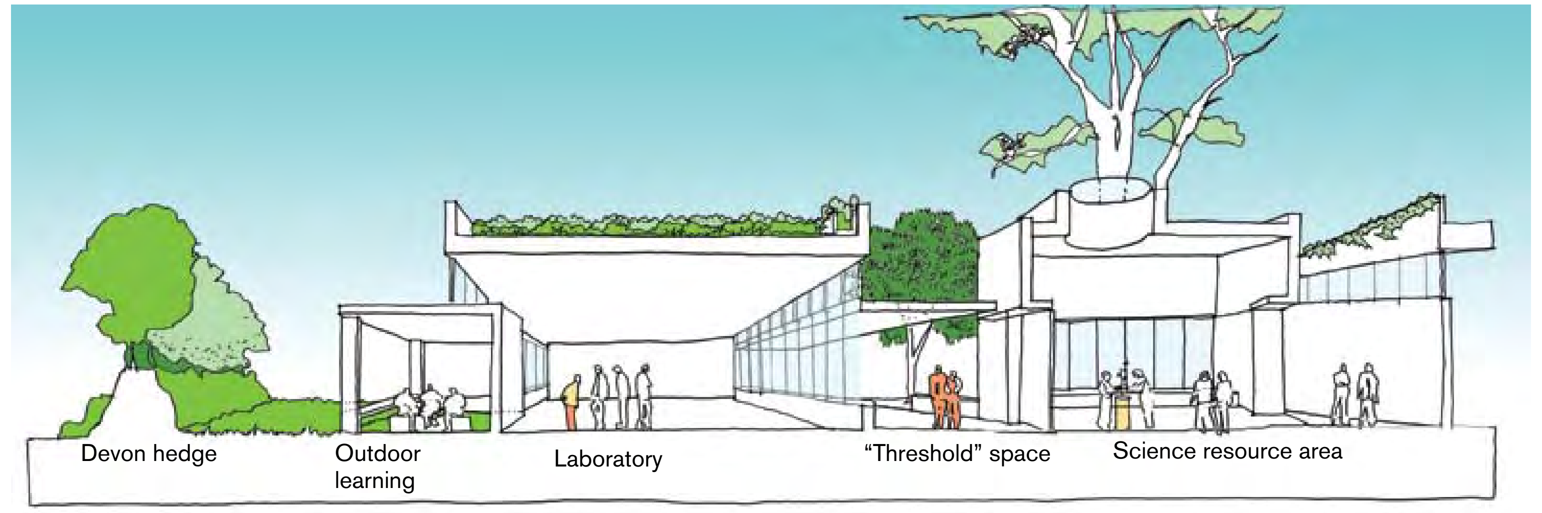
6 Courtyard

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.



Using the whole campus

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.

Number of students 1241
Local authority Barnet
Age range 11–18
Project Faraday coordinator DEGW

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

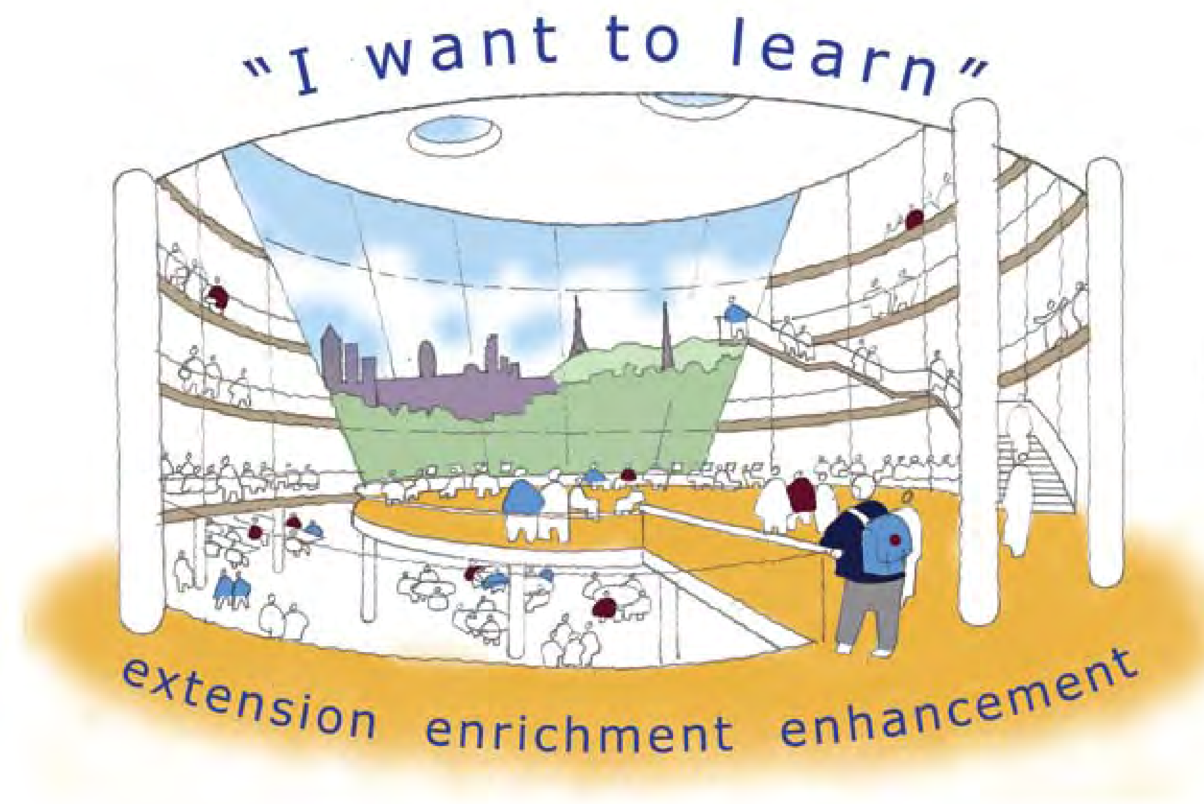


Image credit: Building Design Partnership

Context

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."

Student, East Barnet School

The vision

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.

Design rationale

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.

The designs

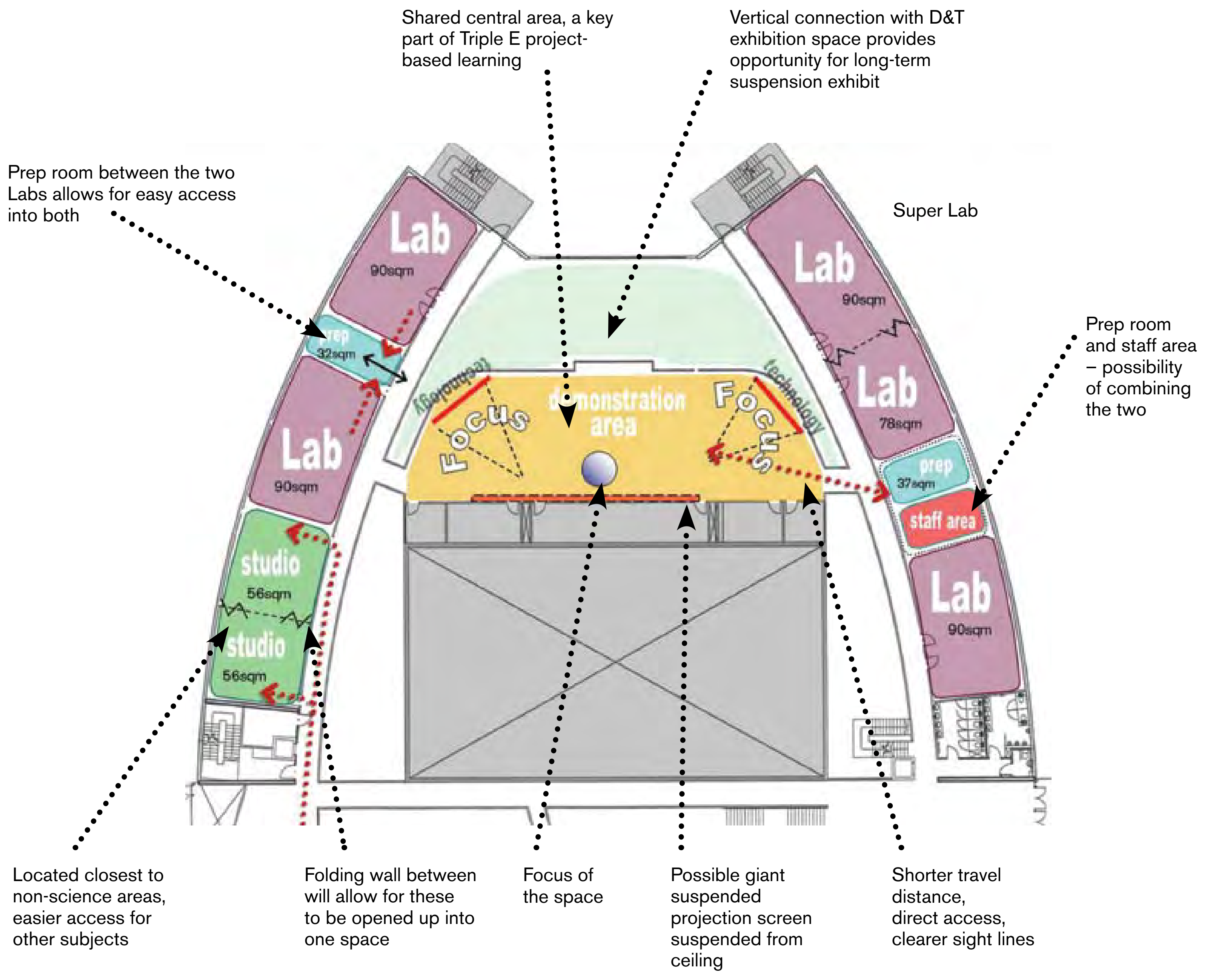
This project team reconfigured space from the traditional model for science facilities used by the local authority, to provide a much more varied set of learning facilities but still with the same total floor area.

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.

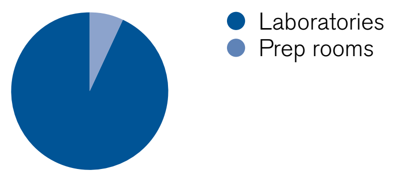
The final aspect of the vision saw the school using the school grounds to bring students close to nature – the 'natural lab' outside could present unrivalled potential to learn about animals, birds, insects and plants.



Concept plan showing key features of the design

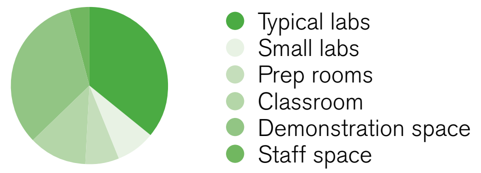
Pre-Faraday schedule of spaces

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

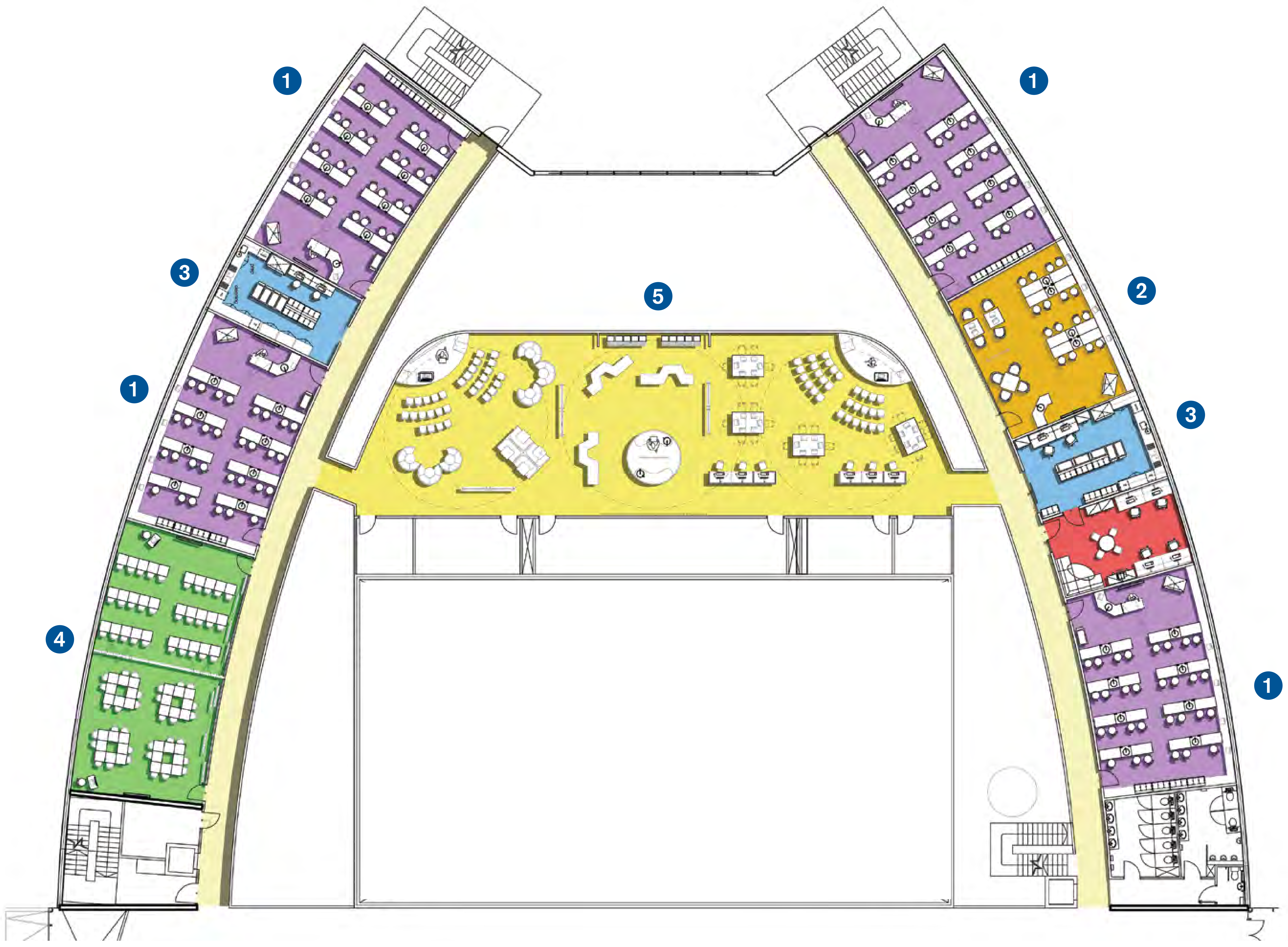


Project Faraday initial schedule of spaces

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



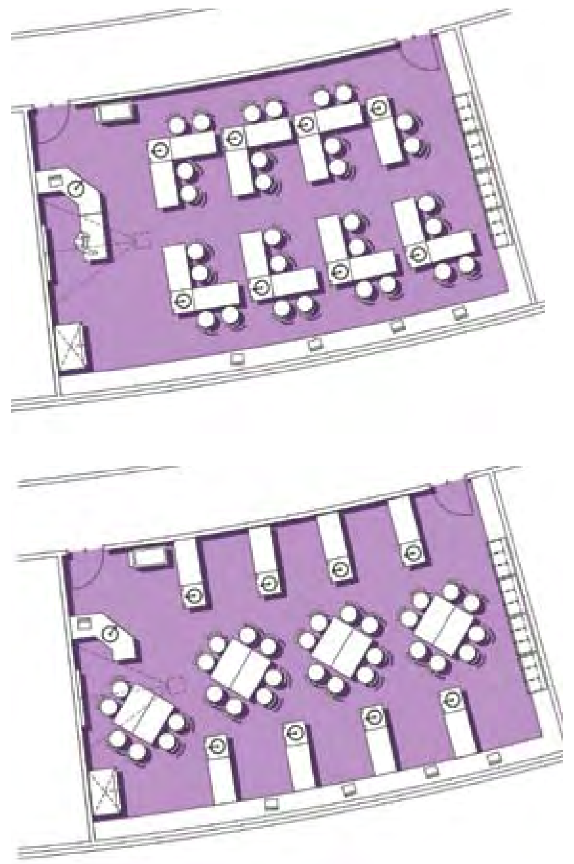
The principle spaces in East Barnet's proposals are four traditional labs, one 'superlab' inspired by commercial science, two science studios and a large demonstration area. The demo area is big enough for a half year group, and has three zones for different activities.



Detailed floor plan

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

1 Four laboratories (90m^2)
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' (90m^2 + 78m^2)
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 (35m^2) and two prep rooms (34m^2)
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.

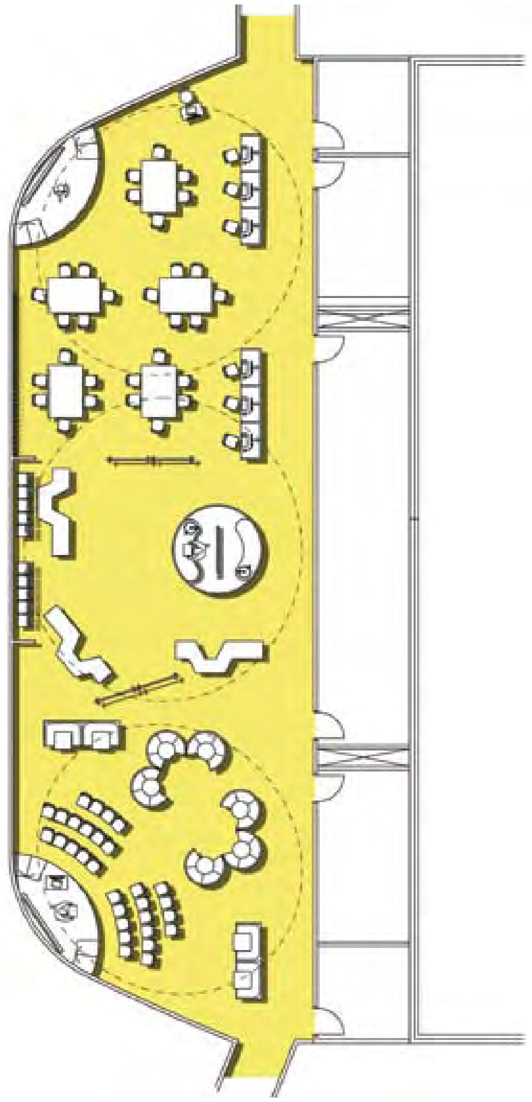
4 Two science studios (56m^2)
Two interconnected theory spaces, each for 30 students (equivalent to non-science classrooms in the school), with no gas or water services. Moveable furniture allows for flexible room layouts, and a moveable partition allows this space to be opened up into one large area. 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 (319m^2)
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.

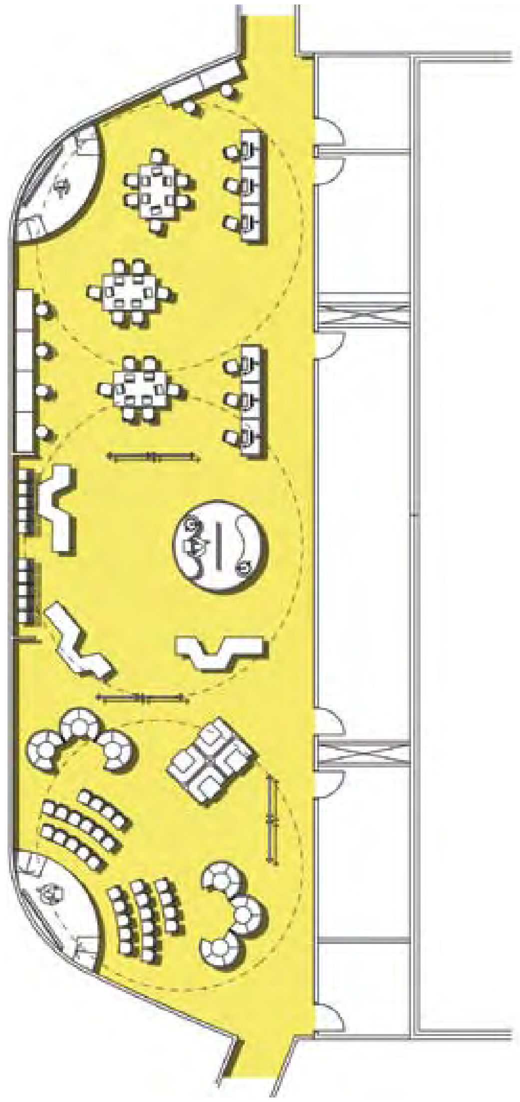
The partition between studios can be open or closed

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

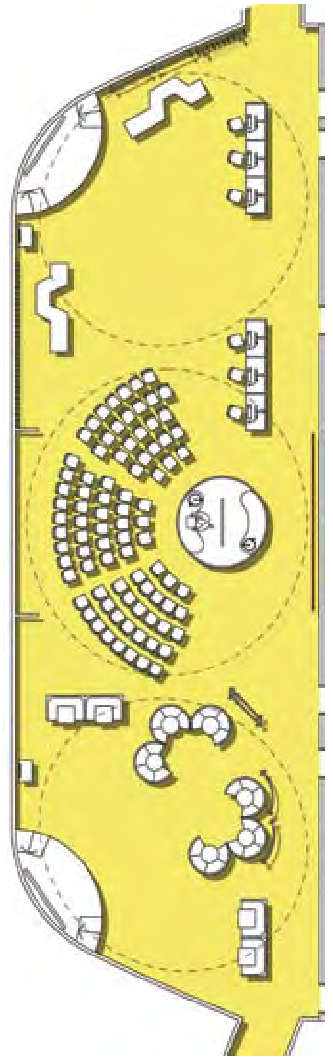
The small lab combining relaxed seating with more formal science benches can be openend up to the adjacent lab to form a superlab



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."

(SLT/Governor, East Barnet School)

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.

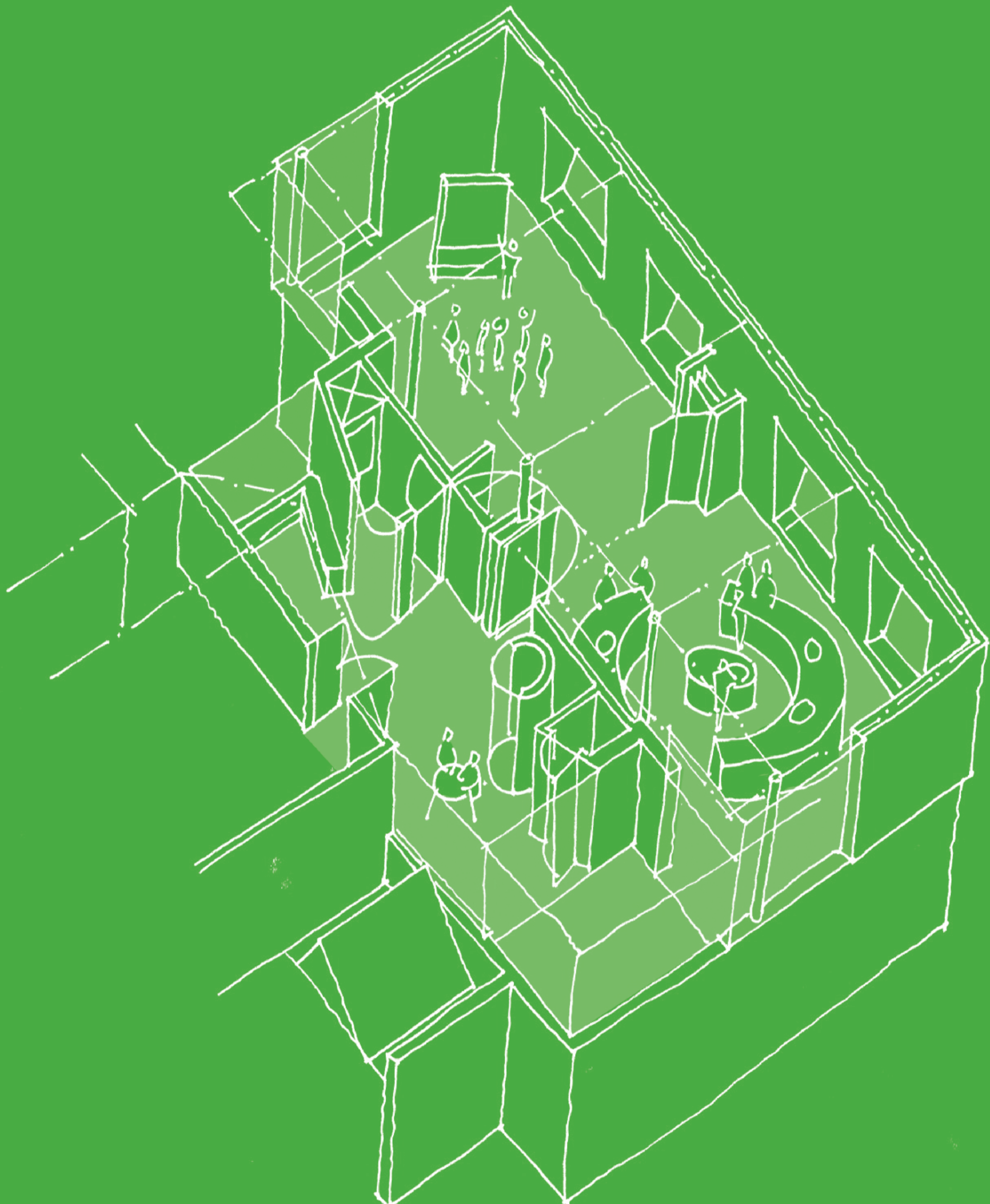
The mid-section, with demonstration podium, projection screen and chairs laid out for a group presentation. A phantom grid on the floor of the periodic table allows quick alignment of chairs.

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/m^2 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

Number of students 1600 (from September 2008)
Local authority Northumberland
Age range 11-18 (from September 2008)
School's architect Waring & Netts Partnership
Cost £1,950,000

Context and vision

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

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:

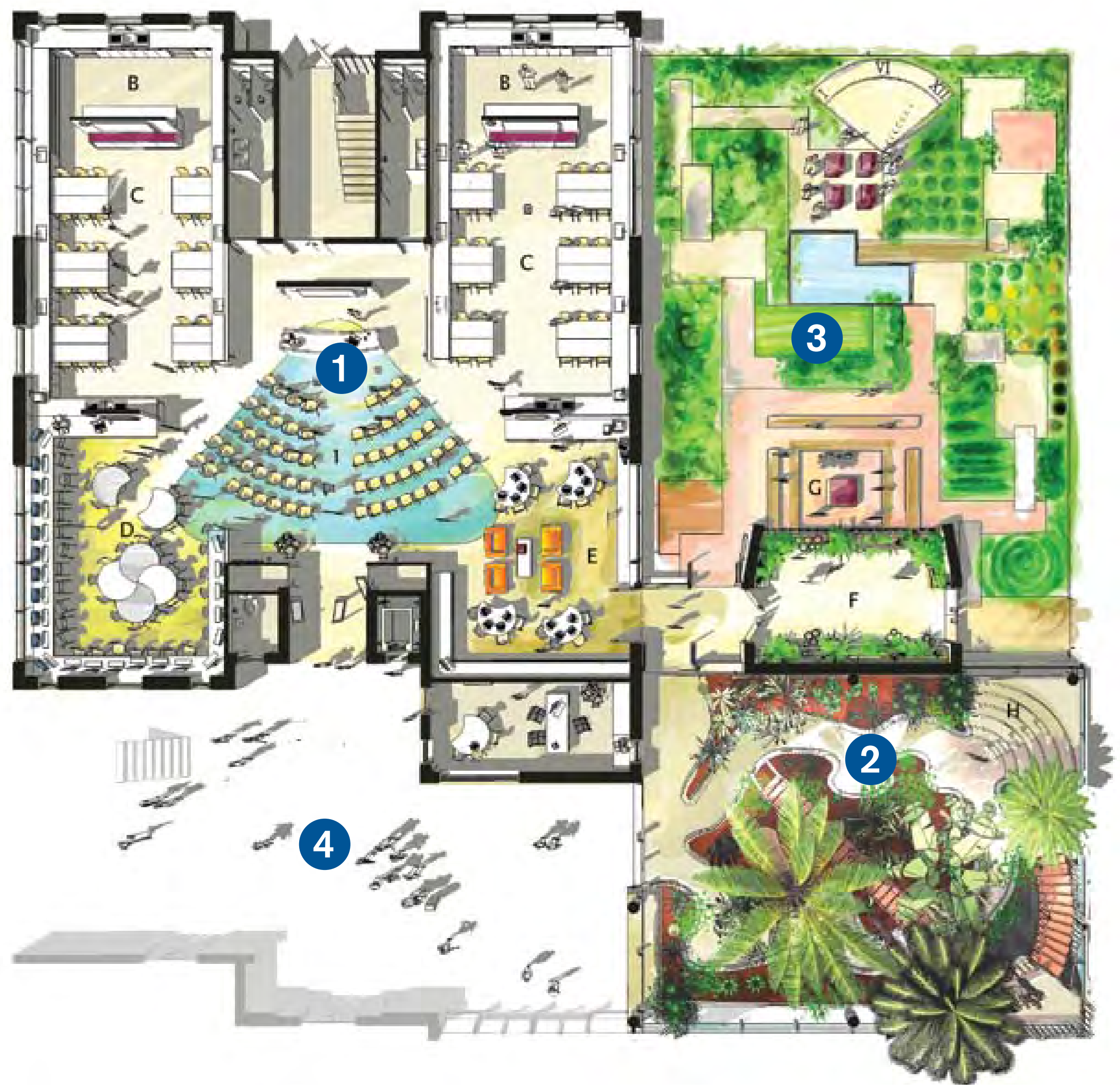
1 The science plaza
A large open plan space for up to 90 students, where students will work on open-ended science projects, supported by a team of three teachers. There are flexible zones for different activities – research, wet work, demonstrations, group collaboration, presentations and group sizes. 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 (101m²)
B Preparation and storage (29m²)
C Practical zone (204m²)
D Resource & ICT learning zone (60m²)
E Discovery zone (60m²)
F Propagation workshop (30m²)
G Outdoor learning base (17m²)
H Indoorl learning base (14m²)

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

Number of students 1100
Local authority Surrey
Age range 11-16
School's architect NPS Property Consultants, Brighton
Cost approx. £800,000

Context and vision

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

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:

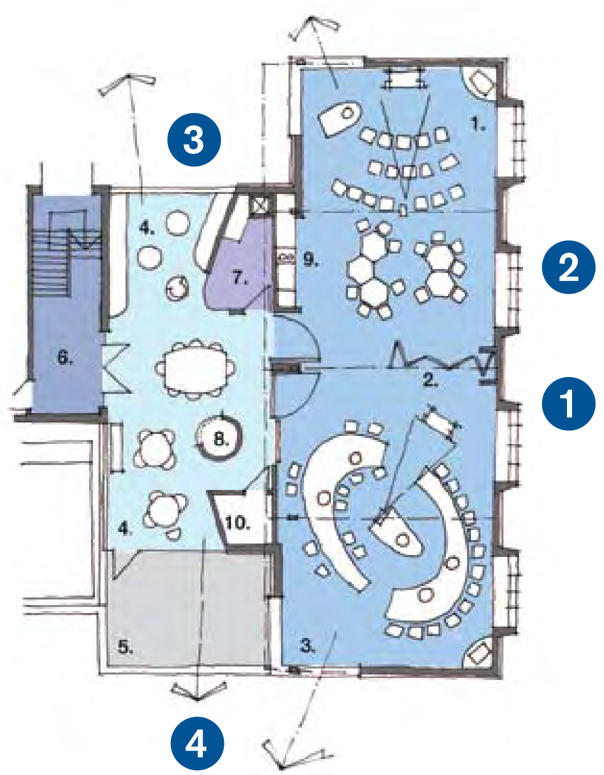
1 A fixed lab zone (98m²)
A highly serviced laboratory with two semi-circular benches for demonstration and practical work as well as class discussions in the round. An acoustic flexible wall means the laboratory can open out into the adjacent studio.

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

Number of students 700
Local authority Reading
Age range 11-18
Design and Build PB&R Design Services
Cost approx. £880,000

Context and vision

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

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

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.

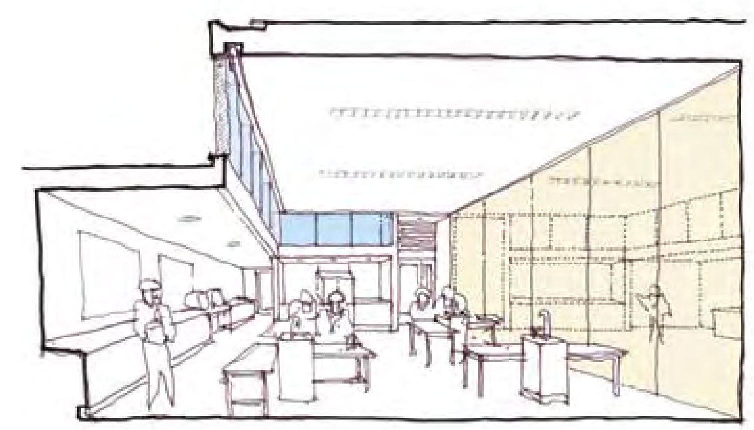
2 A large prep room (38m²)
Windows will allow students to see scientists at work. A fume cupboard between the prep room and one of the labs will give students a good view of experiments.

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 interactive wall in courtyard.


View of one of the laboratories.

Refurbishment case study 04

The Mary Webb School and Science College

Number of students 604
Local authority Shropshire
Age range 11-16
School's architect Simmonds Mills
Cost approx. £1,000,000 (plus £80,000 for ICT and turbine)

Context and vision

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 design

The building will support science learning in two key ways:

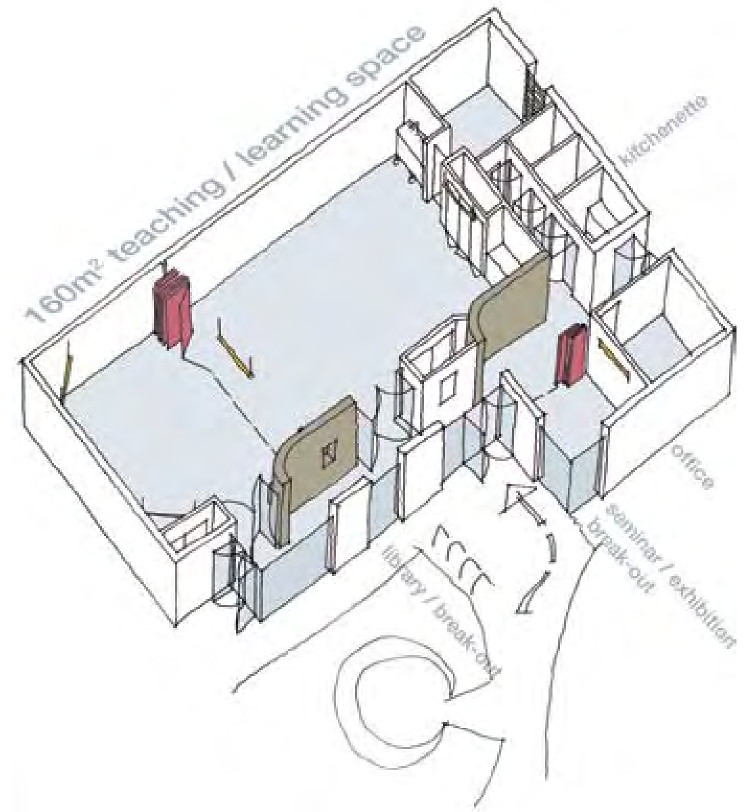
- as an exemplar of environmentally sustainable practice
- as a centre for educating young people and adults about the environment and sustainability issues

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.

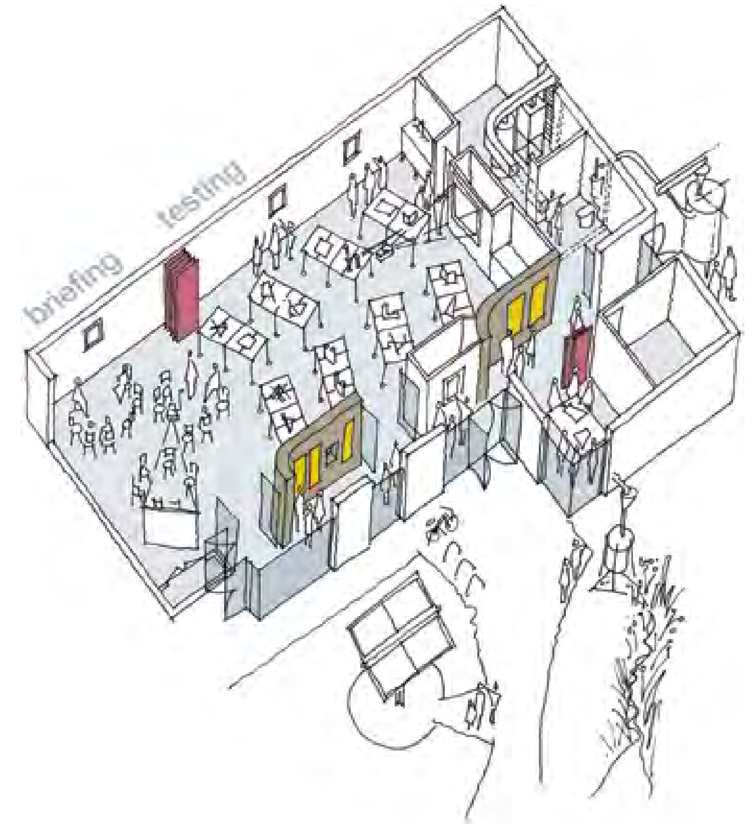
The building will also demonstrate renewable energy sources like wind power, solar panels and photovoltaic cells, and rainwater harvesting and recycling will be incorporated. There will be extensive passive energy features such as a high thermal mass with passive cooling, and natural lighting. There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

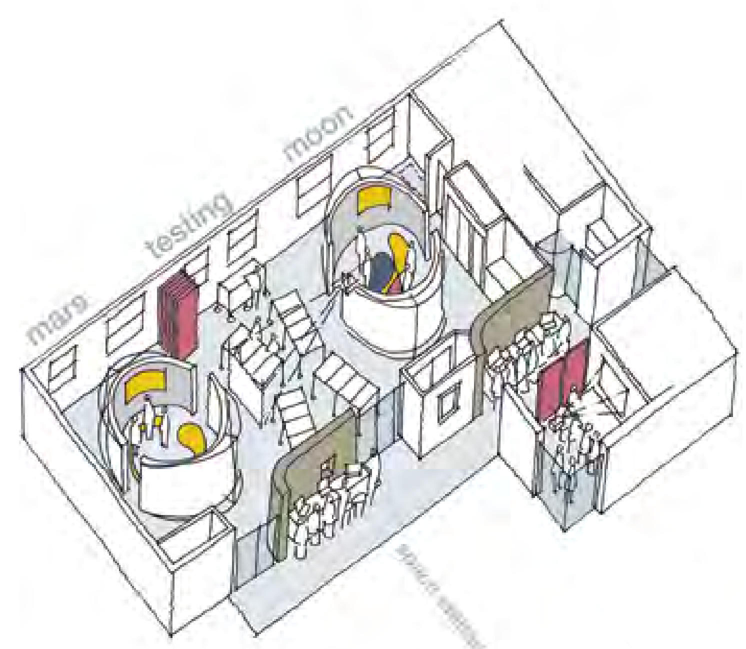
The building, which can be divided into one large and one small classroom, is separate from the existing school but close to the present science block. It's also close to the public library, bridging the gap between school and community. Large-scale experiments will be incorporated into the landscaping.



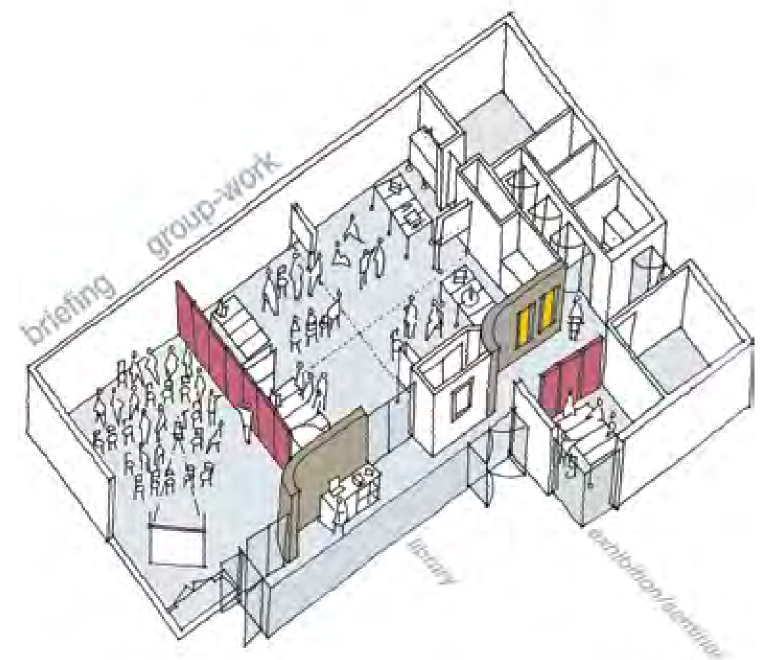
Cut-away view of the eco-lab shell showing key features: a large multi-purpose space with storage walls, breakout space lined with rammed-earth walls, small quiet rooms. The optional layouts shown here demonstrate the centre's flexibility.



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

Number of students 970
Local authority Peterborough
Age range 11-18
School's architect Saunders Boston Limited
Cost £1,175,000

First floor plan

Context and vision

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.

The design

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.

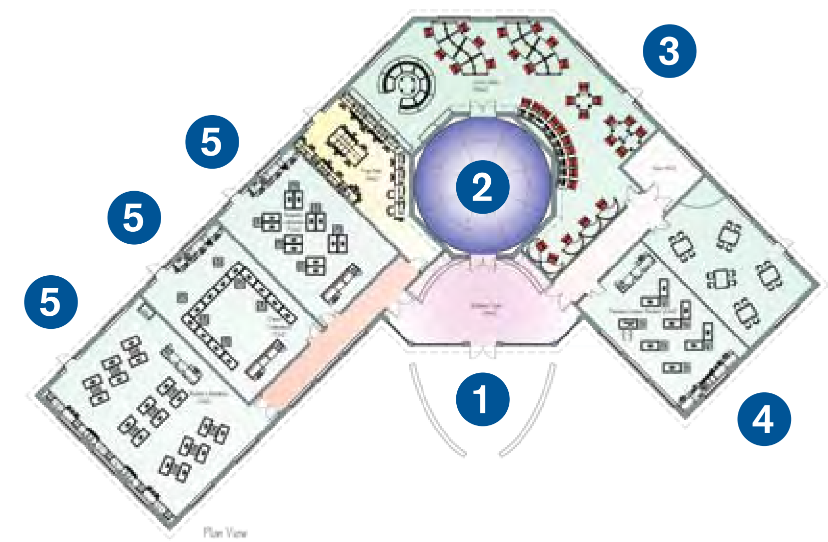
4 ICT zone
On the ground floor, an existing ICT room has been opened up to provide a more flexible and accessible resource which doubles as a conference area.

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

Number of students 1750
450 of them in sixth form
Local authority Lincolnshire
Age range 11-18
Design and Build Lindum BMS, Lincoln
Cost approx. £1,400,000



Context and vision

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 design

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

GovEd Communications

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

What is it?

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.

How does it work?

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.

How is it useful?

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.

Cost

Approximately £7,000 per unit

Interactive experience 02

Force Explorer

GovEd Communications

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

What is it?

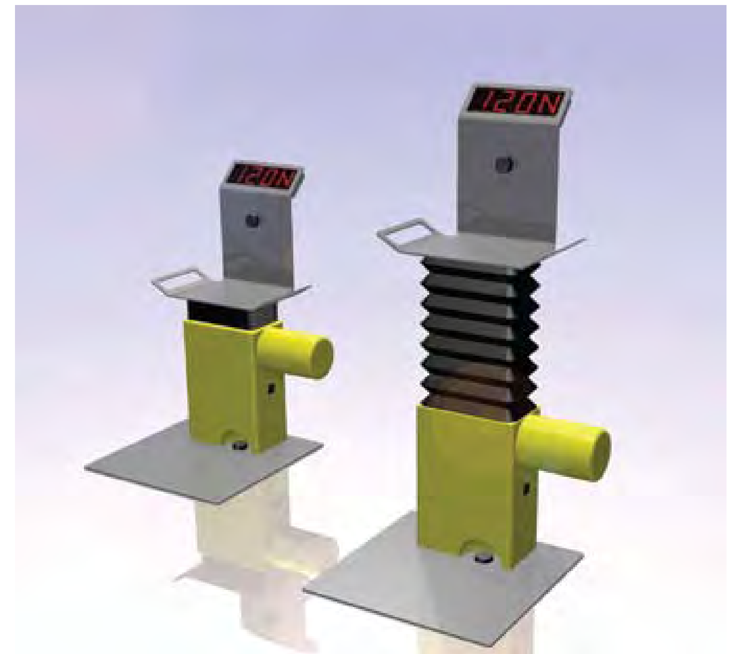
Force Explorer is a rig that allows students to get a direct feel for weights and the strength of forces. They can compare masses and explore pulleys and mechanical forces, making comparisons like "If the Earth had a mass of 1kg, how much would the mass of Jupiter be on the same scale?" (Answer: 318kg.)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

How does it work?

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.



How is it useful?

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.

Cost

Approximately £10,000

Interactive experience 03

DIY Robot Lab

DEGW

Encourages students to be creative and improvise through robotics.

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

What is it?

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.

How does it work?

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.

How is it useful?

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.

Cost

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

DEGW

Makes gravity and acceleration memorable and fun.

What is it?

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.

How does it work?

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.

How is it useful?

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.

Cost

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

Interactive experience 05

Knowledge Garden

DEGW

Provides an engaging, real-life forum for experiments.

What is it?

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.

How does it work?

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.

How is it useful?

Knowledge Garden supports numerous experiments in natural sciences, including:

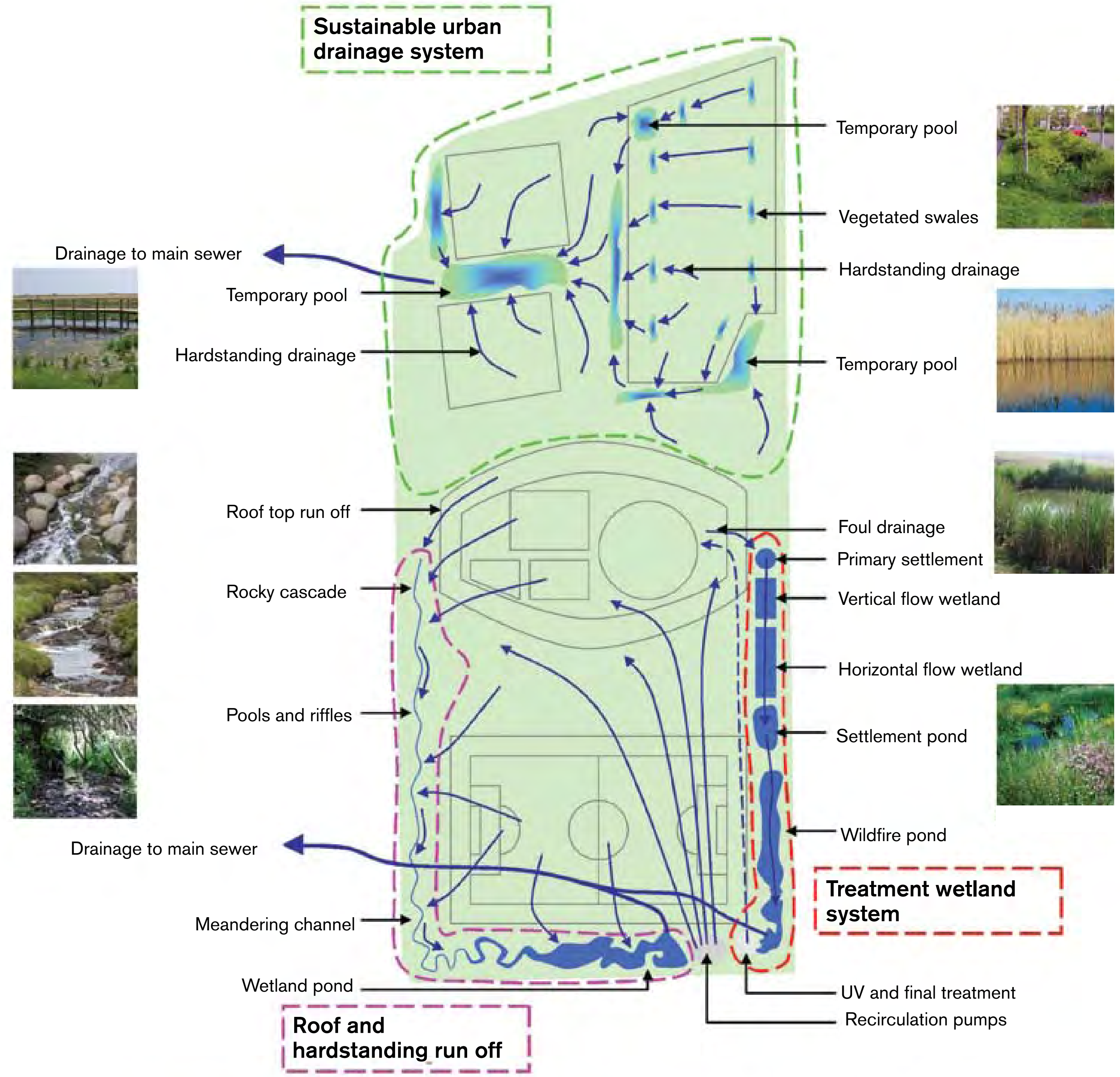
- biochemical oxygen demand
- reproduction studies (plant and animal)
- nitrification
- PH levels

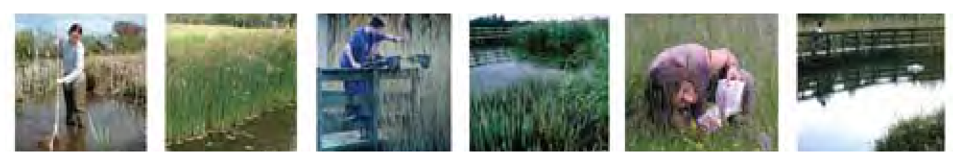
It also provides a forum for aspects of history, geography, business studies, citizenship and mathematics. On top of this, students using Knowledge Garden will develop skills in long-term project management and collaborative learning. The site supports audio, visual and kinaesthetic learning.

Cost

Approximately £20,000

Knowledge Garden: Concept plan for integrated water management.

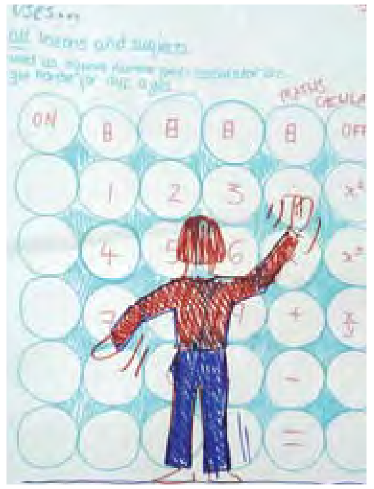




Interactive experience 06

The Matrix

White Design Associates



Allows students to act out the movement of different molecules.

What is it?

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.

How does it work?

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.

How is it useful ?

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.

Cost

Approximately £25,000 including installation

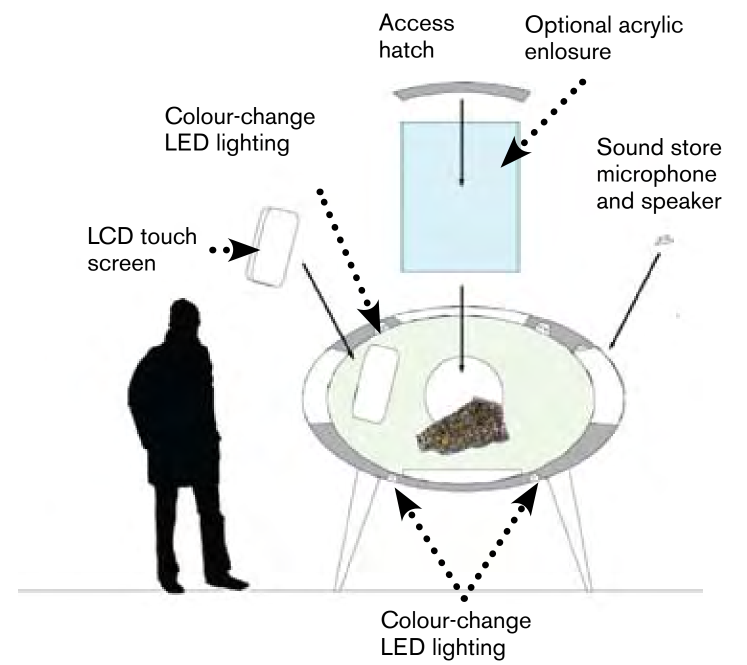
The Matrix is ideal for kinaesthetic learning.

Interactive experience 07

How did that get there?

DEGW

Stretches students' analytical and hypothesis-testing skills.



What is it?

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.

How does it work?

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 is it useful?

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.

Cost

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

Interactive experience 08

Digi-Posters

GovEd Communications

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

What is it?

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.

How does it work?

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.

How is it useful?

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.

Cost

Approximately £2,500

Current view of Sun from Solar and Hellospheric Obervatory (SOHO).

Recent earthquakes regularly updated.

Interactive experience 09

Aerodynamic Investigation Resource (AIR)

White Design Associates

Allows students to take an active part in aeroplane design.

What is it?

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.

How does it work?

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.

How is it useful?

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.

Cost

Approximately £8,000 including software

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

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.

School of Environmental Sciences, Minneapolis, US

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

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 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.

Minnesota Museum of Science, US

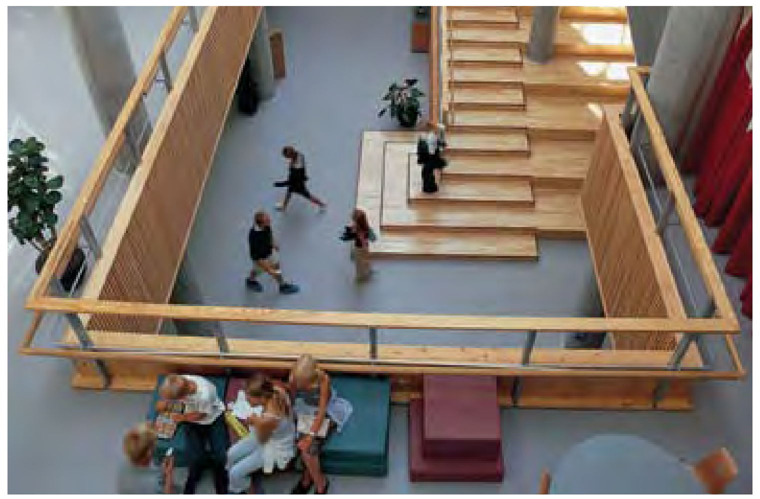
Exhibits relating to the neighbouring Mississippi river help to link the real and virtual worlds.

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 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, Denmark

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:

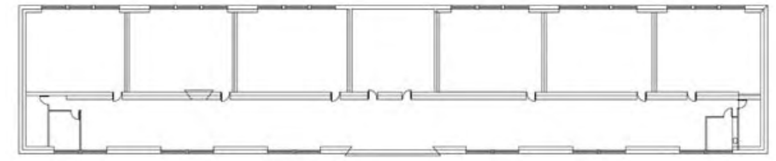
- The design of science facilities needs to be based on a clear understanding of the learning and teaching model.
- Teaching staff have to be involved in moving to a different model of learning and teaching, which typically requires on-site training.
- Facilities continue to evolve once the school begins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

Danish Learning Lab

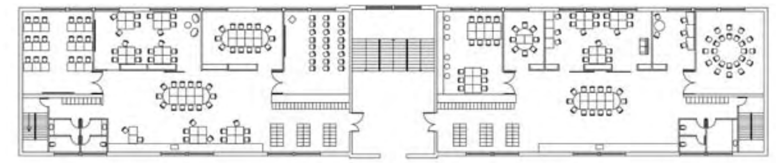
The Danish University of Education has put a lot of effort into building scientific simulations to be used by schools for teaching. As an example, they have a simulation based around forensic investigation. Using the internet, students access progressively more information about a murder in a locker 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.

Maglegårdsskolen, Denmark



'Before' floor plan showing six classrooms.



'After' floor plan showing two home areas.

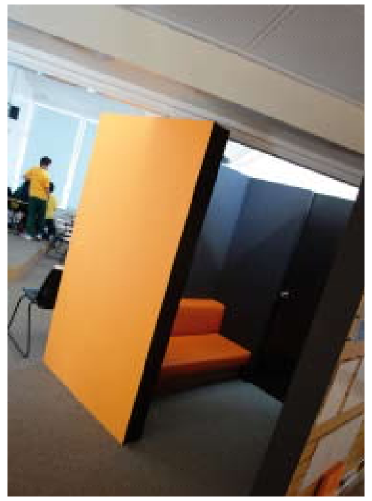
This school was designed by the same team as Hellerup, but it was a refurbishment project that turned a very traditional layout into something much more flexible and better suited to personalised learning – a very economical way to meet similar objectives.

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.

Danish Mindlab

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.

Woorana Park Primary School, Australia

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.

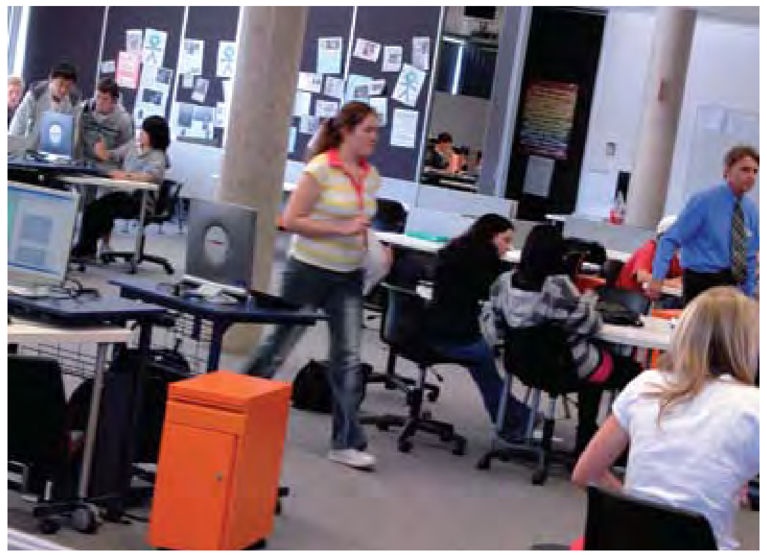
Australian Science and Mathematics School

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.

Victorian Space Science Education Centre (VSSEC), Melbourne, Australia

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.

Rostrevor College, Adelaide, Australia

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

This part of the book brings together:

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.

Key points from Project Faraday

1. It's better to develop design solutions in parallel with the school's current and proposed learning model.
2. A variety of settings – indoors and outdoors – can support inspirational learning and teaching.
3. The whole campus – building and grounds – can provide a rich resource for creative science learning.
4. 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.
5. Staff and students need support through transition and change – both changes to the teaching model and the physical accommodation.
6. 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.
7. Designs need to provide for both current and future learning and teaching needs.
8. Interactive 'experiences' can help students grasp difficult scientific concepts.
9. The best designs facilitate real and virtual partnerships – with scientific establishments, other schools, parents, and others – to enhance learning and teaching.
10. An holistic approach to science, with shared ownership of space and an integrated approach to teaching, improves opportunities for all.

Self-assessment checklists

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 (Y/N)
1 Adequate provision for pupils to store their coats and bags if they are to be brought into laboratories.	
2 Sufficient storage for large scale items (e.g. physics equipment), as well as small scale (e.g. glassware).	
3 Lockable doors for all laboratory and prep rooms, which will be locked when not staffed.	
4 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.)	
5 One large sink with hot and cold water in each laboratory for pupils to wash their hands after practical activities.	
6 One eye-wash station in each laboratory, which must be sited to be readily accessible.	
7 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.)	
8 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.)	
9 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.)	
10 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	
1 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.	
2 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.	
3 Acoustics are critical and particular care needs to be taken with open plan areas or where moveable walls are used.	

Cost commentary

Introduction

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:

Folding acoustic partitions and flexibility

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.

Enhanced services

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.

Purpose-built furniture

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.

External spaces

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.

Postponing works

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.

Total costs

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.

Contacts and references

Organisations

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

Project Faraday publications

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

Publications on Government policy

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

HM Treasury, DTI, DfES (2004) Ten Year Science and Innovation Investment Framework 2004-2014, HMSO, London – the Government's ten year strategy for science and innovation

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

Publications on designing science facilities

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

Publications on technology in science

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)