The Effective Laboratory:
Safe, Successful and Sustainable

Results of the 2012 S-Lab Awards and Conference

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Universities are currently facing many challenges. Competition for students is more intense than ever. The funding environment is uncertain. And students expect that the institutions they choose will offer a consistently high quality educational experience and greater value for money than ever before.

UK higher education and its leaders must respond to this new world whilst always focusing on the reputation for excellence in teaching, learning and research on which our global standing is based. This means seeking out new approaches to old problems. As chair of the Universities UK Efficiency and Modernisation Task Group, I have been at the forefront of our efforts to promote this message.

The challenges are especially great with regard to science, technology, engineering and mathematics (STEM) disciplines, which generally require more complex and expensive facilities than others. It is therefore gratifying that the Awards and Conference presentations have provided so many examples of innovative responses that are providing multiple benefits, including:

- **Benefits to students**, such as those demonstrated by the University of St Andrews’ innovative Chemistry Teaching Laboratory;
- **Benefits to researchers**, including improvements in inter-disciplinary working that have been facilitated by more (and better) equipment sharing at the University of Loughborough;
- **Benefits to institutional effectiveness**, such as the increased space utilisation created by the University of Liverpool’s Central Teaching Laboratory; and
- **Benefits to the environment**, as shown by Imperial College, winner of the Laboratory Environmental Improvement award, which reduced energy costs by nearly £50,000 in a single year.

One especially important theme which stands out is that there does not need to be a conflict between environmental and financial sustainability, nor between ‘green’ facilities and the needs of learners and researchers.

I hope that this report raises awareness amongst university leaders and policy makers that the modernisation agenda can be applied successfully throughout our universities, and that the brilliant examples of good practice demonstrated by the winning, highly commended and shortlisted Award applications will stimulate others to innovate. The reputation of UK universities for world class STEM research and teaching can only be enhanced if it is also taking place in laboratories that are best practice in terms of new criteria such as equipment and resource efficiency, and environmental sustainability.
Foreword

Professor Peter James

Director, S-Lab
(Safe, Successful, Sustainable Laboratories)
University of Bradford

The first section of this report summarises the discussion and presentations at the inaugural Effective Laboratory Conference, held at the National Science Learning Centre in York, UK in June 2012. The fourth section describes the winning, highly commended and shortlisted applications for the parallel S-Lab Awards, which were presented at the Conference.

As can be seen from the cover logos, and list of Award judges on p.13, these activities involved collaboration with many disciplinary and professional bodies, and financial support from commercial sponsors, HEaTED and JISC. The National HE STEM programme also provided invaluable core funding.

Both Conference and Awards originated in, and had their main inputs from, previous work by the S-Lab initiative in universities. However, as the examples in the following pages show, commercial and public sector labs are increasingly involved in our activities.

One striking point is that 96% of post-Conference survey respondents saw scope to significantly increase laboratory efficiency and effectiveness without compromising quality of work and safety. This view is supported by S-Lab audits and workshops, which suggest that hundreds of millions of pounds could be saved over coming years by improving space utilisation, and by reducing unnecessary consumption and waste of chemicals, energy, materials and water.

The Conference discussion and survey highlighted two key factors in achieving these improvements as more focus on the topic by senior staff, and more cross-functional working. Our 2013 Conference, in Liverpool on June 18-19, will address both topics, and provide many more examples of good practice that can provide ‘win-win’ benefits without compromising - and often by enhancing - performance. We hope that we might see you there, and also that you will be encouraged to submit your own achievements to our Awards scheme.

Foreword

Dr. Nazira Karodia

Associate Dean, Life Sciences, University of Bradford and North East Regional Director, HE STEM

The National HE STEM Programme has supported Higher Education Institutions in the exploration of new approaches to recruiting students and delivering programmes of study within STEM disciplines. Its Director, Dr. Michael Grove, and I were therefore delighted to support the S-Lab Conference and Awards. They have highlighted good practice in laboratory design and use for teaching and learning, and brought together the different stakeholders such as academics, science teachers and technical staff.

The Conference combined fascinating content on a range of topics with attendees from a variety of backgrounds. This meant that almost every delegate was coming across new ideas, and often discussing them with people from different backgrounds to those they normally experienced. The result was an intellectual ‘buzz’ which made this into one of the most satisfying events that I, and many others I spoke to, have ever attended.

For me, one especially successful aspect of the Conference and Awards was highlighting the changes which are taking place in school science, and the implications of this for undergraduate study.

The event was held, and had inputs from, the National Science Learning Centre, which advises schools on laboratory design. It also featured a number of interesting presentations from universities that have adapted their first year curriculum and facilities. The debates which this stimulated were especially valuable because they had contributions from a variety of perspectives, including academics, technical staff and designers.

My place is already booked for next year’s conference in Liverpool and I would encourage colleagues who are interested in how laboratories and their use are changing, and who would like to discuss these developments with people from a variety of backgrounds, to do the same.
1. The Effective Laboratory - Conference and Award Themes

Professor Peter James, S-Lab Director

Note that all the boxed quotes are from Conference presenters and session chairs, and almost all of the examples are taken from successful Award applications (with a cross reference to their description in the second section of this report). Most of the others are from S-Lab publications (see p.29). All can be accessed via the S-Lab section of www.goodcampus.org, or www.effective-lab.org.uk. These also have web links for most of the Conference presentations, and for further information on many of the Award examples.

Laboratories in all sectors are taking steps to do more (additional creativity, increased capacity, better performance, higher productivity) with less (money, resources, space, and sometimes staff). That is the message from the 2012 S-Lab Conference and Awards. The drivers - such as financial challenges, changing customer requirements, and increased regulatory and stakeholder pressures - are also common to all sectors, albeit with local variations.

Fortunately, another message is that this tension can be successfully resolved, through good design, effective and inclusive laboratory management, use of modern technologies, and effective continuous improvement mechanisms. The results - such as the airy, naturally lit and ventilated, and highly adaptable spaces of AstraZeneca’s Etherow Building (see below), or the large multiple-use facilities, and associated curriculum changes, of the award-winning University of Liverpool’s Central Teaching Laboratory (see p.20) - are often very different to traditional approaches, and therefore challenging.

A third message from the Conference and Awards is that a critical mass of scientists, technicians, managers and suppliers who recognise that such changes are inevitable, and who are positive about making them happen, is emerging. They are driving a more strategic approach to laboratory management and improvement.

New and Refurbished Facilities Show the Way ... Based on Effective Consultation

Many applications and presentations demonstrated what can be achieved in new or refurbished laboratories. The best designs are those which put people first (including staff who are often peripheral to the design process, such as technical, support or maintenance staff) by taking time to understand their views and working practices, and involving them through design, construction and commissioning. One example is UCLAN’s J.B. Firth Building which undertook detailed analysis of laboratory work patterns in order to optimise layouts and reduce travel distances (see p.22).

Peter Jackson of the HPA (see right) also observed that inclusion reduces the risk of issues emerging when it is too late to change things, and helps to get the right balance between present concerns and future needs. This is especially true when the design team itself is inclusive, with specialist sub-contractors having an early involvement.

Delegates had many anecdotes about labs being sub-optimal (and often expensive to build and run) because customers and/or suppliers were working within their comfort zones and effectively fought the last war by creating more comfortable versions of current facilities. Stories of labs that are not fit for purpose because their design was heavily influenced by the views of senior scientists who, because of job changes or retirement, no longer work in them also abound, especially in higher education.
Improving Staff Creativity, Performance and Well Being

The most important design aim for many new and refurbished laboratories is to improve staff creativity and productivity. The predominant model for achieving this is separation of write-up areas from laboratories, a wider range of meeting and social areas (supported by ubiquitous wi-fi), and open layouts that make activities visible to a wider range of occupants. As many of the later Award examples show, the results can be very attractive and successful in encouraging more interactions between occupants.

Another key design feature for high performance is maximal use of natural lighting and ventilation. Research shows that this can improve morale and health, as well as reducing environmental impacts and cost. The resulting airiness, in combination with visual impact and other features of the new design model, creates too the ‘wow factor’ which many feel is essential to recruit and retain the best staff and, in education, students. Ergonomic layouts and provisioning can also improve productivity and health and safety, for example, by reducing the risks of repetitive strain injury.

A satisfied user in AstraZeneca’s new Etherow Building (subject of a Conference keynote by Neil Crossan) summarised the effects as creating “an enjoyable place to work with excellent opportunities to interact with colleagues in either an open or private manner. The design of the office space has encouraged interaction with new people from different disciplines and background which is very important for the collaborative working to which AstraZeneca aspires.” The quote is from S-Lab surveys of users before they entered, and after they moved into, the building which demonstrate how successful the move was.

Scope for Increased Productivity

Nevertheless, there is scope to improve laboratory productivity further. According to research findings cited by John Trigg (see right), a third of an average researcher’s time is spent on administrative tasks, and another third on communicating with others. Only 11% is devoted to actual research, and 80% of this is the same or very similar to work previously done so that only 2% of available time is devoted to novel research.

Further progress may involve taking advantage of the new flexibility made possible by ubiquitous connectivity and information, and devices such as iPads and other tablets, to bring write-up and other activities back into laboratory areas. This could also cut build costs by enabling smaller write-up areas and less social space, as more interaction would be done through both mainstream and specialised social media, such as those described by Professor Jeremy Frey in his keynote (see below).

Many researchers will find this a strange world, but its advocates believe that laboratory design has to adapt to financially challenging times. One such organisation is Pfizer, which is not only changing its working practices in the way described, but is also developing a strategy of more mobile R&D which is located at relevant ‘science hotspots’. One implication is that R&D will need to move in line with changes in hotspots over time. Hence, the design process for any new or refurbished facility has to consider, and enable, an ‘exit strategy’ to enable this if it proves necessary.

Growing International Competition

Changes such as these are driven by growing international competition, not only for the best scientists and new R&D facilities, but also for the growing number of research tasks which can be outsourced. This new environment was described in Colin Gilmore-Merchant’s keynote on the multi-billion rouble plans for a ‘Silicon Valley’ outside Moscow, which is being developed by the Skolkovo Foundation.

The presentation provided comparative laboratory build and fit-out costs for a number of countries - figures whose very existence shows how globalisation is creating a race for science investment. The fact that Russia’s costs are lower than those of any...
other developed country - and only 79% of build, and 84% of operational costs in the UK - is a key marketing tool level for Skolkovo. The presentation also highlighted the importance of mechanical, electrical and plumbing (MEP) costs. These are typically 30-50%, and sometimes an even higher proportion, of total capital spend for laboratories. The complexity, and the scale of potential capital and operating savings from optimising the design of, MEP systems, reinforces the point about the importance of involving specialist suppliers and relevant internal staff such as maintenance from the very start of a project.

Who Knows What Tomorrow Brings?

As with Pfizer, a key Skolkovo design aim is adaptability, to accommodate both small and large companies, and to allow speedy responses to changing international trends. Presentations by Mike Dockery (see right) and Christian Schnitzer (see left) explored ways of achieving this, with examples from GSK, Siemens and the Universities of Loughborough and Newcastle. Possible measures include 'service ceilings' that allow mobile casework and other laboratory furniture to be easily repositioned; central service cores or spines to service all lab activities; and gridded floorplates to allow easy recombination and division of space.

Better Utilisation of Space and Equipment

Adaptability can help achieve another common design objective, which is achieving more intensive use of (expensive) floor space and equipment. Lilly, for example, now has centralised equipment zones to reduce overall provision and space needs without too much inconvenience as scientists can choose a unit with the shortest queue. The University of Manchester has gone further still with a variety of Core Central Services (CCS) in its Life Sciences Faculty (see p.17). And Loughborough University’s award-winning Kit-Catalogue™ scheme (see p.16) provides an on-line database of equipment to encourage re-use and sharing.

Minimising Environmental Impacts

By reducing overall needs, and enabling more efficient operation, better space and equipment utilisation can also minimise laboratories’ heavy environmental footprint. This includes energy use (over £1 million a year in total for larger facilities); consumption of large amounts of chemicals, materials and water; and production of large quantities of waste, some of which is hazardous.

The special laboratory credits in the latest BRE Environmental Assessment Method (BREEAM) - which S-Lab helped to develop - help designers to ameliorate these impacts at design stage. The S-Lab laboratory environmental assessment template, and accompanying best practice guide, has also highlighted the many operational changes that can be made to reduce impacts. It is being rolled out within universities and other sectors as part of the ‘Labs Tab’ on the Green Impact Awards scheme delivered with NUS (the National Union of Students). Presentations on its pilot use by Martin Wiles of the University of Bristol and a University of Manchester team (see p.19) noted that it can also have broader non-environmental benefits in building links between different labs, which often have little contact with each other.

Rethinking Ventilation

S-Lab audits have shown that ventilation accounts for 40-60% of laboratory energy bills. Air flow rates have increased greatly in recent decades due to tightening health and safety requirements. However, application of the risk assessment approach (as opposed to traditional rules of thumb) of the still relatively new standard on containment, BS EN 14175, often permits the safe reduction of air flows (see right, and the example of the University of Newcastle’s Baddiley-Clarke Building on p.21). A box on p.17 provides examples of ventilation improvement measures that were highlighted in Conference presentations and Award applications.
Imperial College’s award-winning Continuous Commissioning programme (see p.14) certainly shows the benefits of investing in a systematic approach to ventilation improvement. Changing user attitudes and behaviour can also make a big difference, for example, by encouraging sash closure on VAV fume cupboards (see a Manchester Metropolitan University example on p.15).

The Lean Laboratory
Shaun White, of the Food and Environment Research Agency (FERA), attributed its successful transition from primarily governmental to semi-commercial to a wide ranging continuous improvement programme. This includes innovative employment policies and a common laboratory information management system (LIMS) which enables much better sharing of data and tracking of delivery. Many others are travelling a similar path, sometimes applying the concepts of lean manufacturing to laboratory operations, and/or adopting formal systems such as the ISO 9001 quality management system (see Plymouth University example on p.18). Continuous improvement can also be incentivised by more transparent accounting for central services, e.g. by charging for space, energy and other resources, or sharing a portion of any savings that fall under central budgets with departments or individuals.

Financial and Other Benefits from Chemical and Sample Management
There is certainly much more intensive recording, tracking and analysis of laboratory operations than in the past. Chemical management systems such as that of the University of Edinburgh (as described in an S-Lab case study) can save hundreds of thousands of pounds in larger labs by reducing wastage, and provide other benefits such as faster chemical access for researchers.

More effective sample storage and management can also reduce overall dewar, fridge and freezer requirements by ensuring that only wanted samples are stored. Together with other measures, such as using storage space efficiently; storing materials at the highest temperature that meets preservation requirements; maintaining cold storage devices so that they operate efficiently; and only purchasing very energy efficient models, great savings can be made. Bob Nicholson’s presentation highlighted how a programme of replacing older freezers with very energy efficient models at the University of Newcastle saved £13,000 and 70 tonnes of CO2 emissions a year, and freed up space by replacing chest with upright models.

Can Laboratory Informatics Deliver Benefits?
Andrew Platt highlighted the benefits of a LIMS - including more accurate and standardised information, and better security - in managing over 200,000 samples in the University of Manchester’s CIGMA unit. The holy grail for practitioners is linking LIMS, electronic lab notebooks (ELN) and other lab IT systems together into a unified laboratory IT architecture, which also interfaces with organisation-wide systems such as document storage.

The claimed benefits include smoother, easier workflows with less manual effort and duplication of data entry; error reduction; reduced IT development and support cost; better data management and recording (e.g. to demonstrate compliance, or support patent applications) and greater security. However, progress is impeded by a lack of common communication, data transfer and terminology standards, and fragmentation of knowledge and interest around specific systems.

Keynote Jeremy Frey stressed the advantages of ELNs in providing background information about intentions, context, problems surmounted etc. This can sometimes be as or more important than science data itself to subsequent researchers, and also important in providing reassurance that findings are not fraudulent. He also highlighted the benefits of ELN integration with other processes (e.g. health and safety plans which often provide details of intentions, set ups etc.) and other IT systems.

The University of Southampton’s LabTrove project is a step towards this by providing...
a blog-type system which creates a continuous written record with the facility of hyperlinking to other entries, or external sources, and annotation by the author and authors. The software also creates QR codes for each blog post, which can be printed and stuck onto physical objects, thus connecting the digital with the physical.

Many pieces of equipment also have their own blog entries, with automatic uploading of data, allowing people to comment on, or link to, results. One prerequisite for these developments, Frey noted, is IT ubiquity, with high capacity wireless, 3G and (soon) 4G provision in all areas, and the ability to use tablets and other devices even in wet labs.

Here Comes the Cloud
Ubiquitous connectivity is also reducing the need to have so many servers and HPC clusters within laboratories. By allowing multiple software to run on the same server without interfering with each other, virtualisation allows the total amount of servers, and therefore energy, needed to be reduced. Connectivity also allows many tasks such as analysis and storage to be carried out remotely, either in a central organisational facility or an external provider in the 'cloud'. This could reduce science computing costs as a result of economies of scale and scope (including providing the opportunity for users to avoid investment in servers used only intermittently). It might also provide greater reliability due to multiple mirroring and back up. And there could be less environmental impact overall due to greater efficiencies and the ability to optimise locations to minimise cooling and maximise use of renewable energy.

A presentation by Geoff Cartwright on his JISC report on cloud economics for science and other HE computing noted that, in practice, cloud can appear to be more expensive than local servers for regular use by scientists. However, this was in part because external solutions incur VAT, and also include the energy and other support costs which are usually paid by estates and so are invisible to researchers. On the other hand, local solutions could be made more cost and environmentally efficient. Presentations on central HPC facilities at Leeds and Leicester Universities by Alan Real and Chris Rudge, or by John Summers of Leeds on server cooling innovations such as that of Conference sponsors Iceotope, provided examples of how to do this.

When IT Rules the World
IT advocates believe that the barriers to computing and data ubiquity, systems integration and greater use of cloud in laboratories are temporary, and that science will be very different in future as a result. The ideas being discussed in the IT conference breakout stream included:

- More automation and/or outsourcing of repetitive activities to low cost providers;
- Greater use of robotics in secure areas for potentially hazardous procedures, with scientists controlling them from their desks; and
- More simulation of biological or chemical processes for both research and teaching.

The latter featured in presentations by the University of Bradford (see right) and Southampton (see p.27).

Rethinking Teaching
Widespread use of IT for presentations, and for student access, is also a feature of the new designs which are changing the 'look and feel' of teaching laboratories. Several universities have developed large teaching spaces which can accommodate multiple groups, and be used by a variety of disciplines and year groups. Examples include two S-Lab Award winners - Liverpool’s Central Teaching Laboratory (see p.20) and St Andrews’ Chemistry Teaching Laboratory (see p.28) - as well as the Science Complex at the University of Sunderland (see right). The Royal Veterinary College’s new Teaching and Research Centre (p.21) has taken a different approach, seeking greater linkages between its specialist research, and students’ learning.
The Refurbished Laboratory Awards category demonstrates that new buildings are not essential to combine innovation in teaching methods, a better staff and student experience, teaching and equipment efficiencies and minimised environmental impact. Examples include the category winner, the Cell Culture Teaching Laboratory at Sheffield Hallam, the Biomedical Sciences Labs at Leeds Metropolitan, the Chemical Engineering labs at Aston, Physical Sciences labs at Kent (all on p.23-24), and Chemistry labs at Warwick (see p.15).

The Awards also highlighted the changes taking place in secondary and further education science teaching, with excellent submissions from Kendrick School, and Canterbury, Halesowen, Oldham (the winner) and Truro and Penwith Colleges (see p.25-27). Presentations by Mark Langley (see p.22) and Jacquie Robson (see over) discussed the need to adapt the content and practices of university first year courses in response to this.

New Career Structures for Multi-Skilled Technical Staff

In student surveys technical staff are often selected as the most helpful source of learning support. This is just one example of the multi-faceted roles that are now typical in laboratories of all kinds, resulting in higher and more varied skill requirements. Different points of entry are developing as a result, such as apprenticeships and more structured graduate and postgraduate recruitment.

Greater development support is also emerging for those already in post, for example, from the HEaTED initiative (see right), the Professional Technician model being developed by the Technician’s Council, and the professional registration schemes of the Science Council. The latter has two new categories of Registered Scientist and Registered Science Technician to complement its existing Chartered Scientist category. An innovative partnership between the University of Sheffield and the Institute for Science and Technology (IST) is building on these initiatives by defining ‘technical career pathways’ to highlight the development opportunities that are available to existing staff and potential recruits.

Liverpool’s Central Teaching Laboratory demonstrates how these changes support improvement. Its goals of high utilisation could only be achieved through flexible and multi-skilled technical staff, who now have slightly longer hours on a two shift pattern in term-time in exchange for additional annual leave during vacations. The submission noted that “time spent on reviewing support staff skills and project needs is a valuable investment which encourages team working, improves motivation, provides opportunities for staff development and flexibility and facilitates the revision of working practices. Technical staff have welcomed the opportunities for personal development.”

These changes are being accompanied in some universities, such as Manchester Metropolitan and Sheffield, by new career structures in which technical staff are managed centrally, and assigned to specific labs, rather than being tied to departments permanently. A parallel trend is the creation of multi-laboratory specialised management posts - such as the Core Services Manager role in the University of Manchester’s Life Sciences Faculty (see p.17) - and/or high level operations management posts within larger faculties or departments, as at the University of York (see right).

Cross-functional Working

Technical managers with greater authority and management competence can also operate more as equals with scientists, estates and other stakeholders. This is vital, because many of the improvements discussed so far require cross-functional collaboration. The relationship between Estates/Facilities staff and laboratory users (academics and technical staff) is especially important because it is the key to successful design of new and refurbished projects, and achieving many operational

“Technical staff can be isolated within their labs. Activities that bring them together both within institutions, or externally, can have great value by allowing experience to be shared and learnt from. It also builds people’s confidence to make changes within their workplace.”

Dr. Katherine Forsey, HEaTED Course/Network Co-ordinator

“Development of technical staff is crucial to achieving more effective laboratories. Whilst specific skills are the focus of early careers, progression requires better communication and management skills and greater business and commercial awareness.”

Ali Orr, Registrar, Science Council

“I lead over 50 professional and administrative staff and see my key roles as providing direction, coaching, and building good relationships between my team and their internal and external customers and partners.”

Dawn Cartwright, Director of Infrastructure and Facilities, Department of Biology, University of York
improvements. A combined presentation by Estates (Nick Hillard and Gez Hunter) and technical (Dr. David Josey) staff about Warwick’s Chemistry lab refurbishment (see p.15) epitomised this in practice.

At the other extreme one presentation noted how Estates refused lab users access to building management data (and even changing locks to prevent a water meter being read in one case!), whilst another described how academics installed energy intensive equipment without consultation and then expected Estates to provide power supplies, at considerable additional cost.

Fortunately, interface roles are emerging, or becoming more widespread, to overcome such problems. One is a dedicated laboratory Building(s) and Facilities Manager, as demonstrated by a presentation from Richard Jones (see right) who played this role within Oxford’s Chemistry department before moving to Estates to provide lab expertise for new projects. Several other scientists or technical staff have followed this route in other universities.

Philip Pike provided an example of the benefits of Estates proactivity from Oxford’s ‘Midnight Oil’ project. Lab ventilation and other systems often operate 24/7 at full tilt because it’s assumed that this is a research requirement. However, a survey found that this was only true of 1 in 7 scientists, suggesting that operational settings could be altered in some lab areas.

A parallel development on the user side is academic managers with Estates-style capital project management skills. This was demonstrated in a keynote presentation by Professor James Naismith (see right) on his role in driving St Andrews’ new Biomedical Science Research Complex which he now directs (see p.22).

Increasing Laboratory Security

One area where cross-functional collaboration is especially vital is that of security. Conference keynote Guy Collyer highlighted the potential for laboratory materials to be used for bombs or chemical weapons, for biological organisms to be used for bioterrorism; and for laboratory equipment (obtained by theft, or second hand) to support both these purposes.

The risks can be reduced by deterring, detecting if a problem does arise, and delaying any consequences through counter measures. Central to this is storing relevant substances securely, tracking their location and use, and restricting access where necessary. An important part of detection is being alert for any changes in behaviour by users - something which can also be helpful for good HR or student support as these are usually related to domestic or health issues.

The Importance of Individuals

At the end of the day, none of the actions described above can be taken without the commitment and energy of people within laboratories. This was recognised in the Awards’ ‘Making a Difference’ category, which highlighted:

- The role of Plymouth University’s Dr. Mike Foulkes (the winner) in setting up an ISO 9001 certified quality management system in Environmental Chemistry that has transformed working practices and training, and aided income generation (see p.18).

- The campaign of UCL’s Professor Andrea Sella (Highly Commended) to reduce the Chemistry Department’s water use by over 70%, with minimal expense (see p.19).

- The intermediary role between labs and Estates played by the University of Manchester’s Dr. Arthur Nicholas, who is leading what may be the sector’s most developed cross-functional initiative to improve laboratory sustainability (see p.19).

- The many improvements associated with John Smith - the shared Building Manager of a number of departments at the University of St Andrews - including a new design of fume cupboard that is saving many thousands of pounds in energy costs (see p.19).
Safe, Successful and Sustainable - Examples of Win-Win Actions

- Chemical management systems can save money and minimise environmental impacts by reducing waste and unnecessary storage; by improving safety and security because the location of dangerous chemicals is tracked; and by enabling researchers to get supplies more quickly or cheaply from colleagues rather than ordering (with reassurance as to how they have been used and stored).

- Lower flow fume cupboards whose safety has been risk assessed can reduce energy consumption and costs, and reduce the risk of uncontrolled break-outs in some circumstances compared to high flow alternatives.

- More sharing of equipment can reduce costs and environmental impacts because less is required, and can also create more interaction between users.

- Ensuring that freezers and fridges contain only wanted samples that are tracked and easily accessible can reduce the amount needed (and their associated energy costs); make it easier to comply with regulations; and avoid the risk of spoilage because doors are open too long.
2. Key Features of Effective Laboratories

An effective laboratory is one which is highly productive with regard to its purpose; has high levels of safety and user health and satisfaction; and is lean in resource use. The Conference discussions, and other S-Lab activities, suggest that many current laboratories do not meet this definition, when compared to best practice or their potential. The following points are a first attempt to distill the discussions into performance criteria and feedback is welcomed on them.

- Laboratories are managed strategically, with larger ones having a senior management group that has an integrated perspective on laboratory operations because it contains both users and technical support staff.
- There are effective cross-functional and cross-laboratory connections so that experience and information is shared, and different stakeholders work effectively with each other.
- User performance and satisfaction is proactively monitored and processes are in place to express concerns and issues, and to respond to them effectively.
- Significant decisions, such as new build or refurbishment, or major equipment acquisition, have inputs from a variety of stakeholders, examine alternative options, and are ‘future proofed’ by considering how laboratory use could change. As a result, they are not dominated by special interests or views that may not be relevant in 5-10 years’ time.
- There is a well-integrated IT infrastructure and high levels of connectivity which allow staff to work flexibly and which support the achievement of the following goals.
- There are mechanisms in place which support continuous improvement of operations by collecting and reviewing relevant information, and bringing it to the attention of senior management.
- There is a high level of utilisation of space, equipment and other assets, supported by effective mechanisms to encourage ‘right sizing’ for tasks and sharing.
- The location, ownership and use of all chemicals, materials and samples is tracked, and the information is used to manage and use them efficiently, and to minimise pointless storage and wastage.
- Environment, health and safety are recognised as strategic issues which are considered at an early stage of decisions so that ‘win-win’ synergies with other aspects of laboratory operations can be identified.
- Users are aware of the costs of laboratory infrastructure and services, and the operation of the latter can be adjusted in response to variations in needs and use.
- Technical support staff have career development opportunities, and a career structure, which encourages them to broaden their skills and to gain experience of different working environments.

Conference Keynote: Smart Labs at the University of California, Irvine (UCI)

Stimulated by large cuts in state funding, UCI set goals of reducing energy use in new labs to 50% or less of regulatory requirements, and improving the efficiency of existing facilities. The ‘Smart Labs’ initiative which resulted is an integrated set of laboratory design criteria and performance standards. Its centrepiece is real-time air quality sensing which allows the normal level of air changes per hour (ACH) to be 2-4 (below the 6-10 in older labs), but with the ability to reach 12 ACH or more if levels of VOC and other contaminants rise. Other ventilation features include reduced fan, filtration, and duct air speeds below current best practice standards; and reduced stack discharge airspeeds in normal use. The lower air change rates are also enabled through reduced internal heat loads achieved by improved daylighting and low energy illumination; occupancy sensors; Energy Star equipment; point-source exhaust grilles directly above heat-discharging equipment; and reduced thermal inputs during setback periods.

Vice-Chancellor Wendell Brase says that: “The rich information layer within a ‘Smart Lab’ allows quicker responses to both emergencies and routine performance issues, making buildings safer than prior designs. We’re also finding that, having hit our 50% target - for example, with our new Sue & Bill Gross Stem Cell Laboratory (pictured) - the data is highlighting further improvement opportunities.”
3. Sponsors and Supporters

The National HE STEM Programme, a HEFCE-funded initiative to support Higher Education Institutions in exploring new approaches to recruiting students and delivering programmes of study within STEM disciplines, provided core support for the Conference and Awards. See Dr. Nazira Karodia’s foreword for more information.

S-Lab would also like to acknowledge the generous support of the following organisations who helped to make the Conference happen. They have supplied the following text:

**Platinum Sponsor**

**HOK** is a global provider of architecture and laboratory programming, planning and design services to science and technology clients. It employs more than 1,700 professionals linked across a network of 25 offices on three continents. Recent projects include:

- The California Institute of Technology - design lead on the Kavli Nanotechnology Institute.
- The Francis Crick Institute - design lead on this flagship life sciences facility located in central London which involves a partnership between six major UK scientific institutions.
- King Abdullah University of Science and Technology - design lead on this LEED Platinum development near Jeddah, Saudi Arabia.
- Skolkovo Technopark - initial concept design for a multi-billion rouble innovation park near Moscow, Russia.

[www.hok.com](http://www.hok.com)

**Gold Sponsors**

**AECOM** creates, enhances and sustains the world’s built, natural and social environments. It combines technical expertise and creative excellence to develop design approaches that will support and enhance the operational and sustainability objectives of projects, and provide low energy solutions. One recent project is Lilly’s Windlesham refurbishment, as described in a keynote presentation at the Conference.

[www.aecom.com](http://www.aecom.com)

**Critical Airflow** is part of the Four Seasons Group and specialises in laboratory control and critical airflow applications. Its systems ensure the environmental integrity of critical facilities based on proven products developed by Phoenix Controls and Strobic Air Corporation. They are also the UK agents for the Aircuity demand-based ventilation system that has been installed at the University of California, Irvine (see p.11).

[www.criticalairflow.com](http://www.criticalairflow.com)

**Field Management Services (FMS)** mitigates electromagnetic and radio frequency interference in research laboratories and other facilities. Many US labs, including Harvard, now invest in mitigation and FMS is transferring their experience to Europe, most recently through a University College, Dublin development. It combines engineering experience and credentials with hands-on technical skills, to provide specialised advice and consultancy and the lowest cost mitigation solutions.

[www.fms-corp.com](http://www.fms-corp.com)

**Iceotope** provides the world’s first data centre within a cabinet that scales from one to thousands of computers and delivers “Full Time Free Cooling Anywhere”. This combines next generation liquid cooling technology, industry standard products and their own IP to drastically reduce power consumption and associated CO2 emissions. Designed, engineered and manufactured in the UK, Iceotope’s equipment avoids cooling infrastructure associated with traditional data centres.

[www.iceotope.com](http://www.iceotope.com)

**Waldner** specialises in state of the art laboratory furniture, fume cupboards and smart controls. It has been at the forefront of sustainable and flexible laboratory design and practice for decades and has installations in many UK and international commercial, public sector and university laboratories (including Warwick - see p.15). Its Scala products offer innovation, mature technology, operational safety and ergonomic design, supported with a comprehensive service ensuring optimum functionality.

[www.waldner.co.uk](http://www.waldner.co.uk)

**Supporters**

**HeaTED** The Conference received financial support from HEaTED, an organisation supporting professional development of the technical workforce in education and related fields.

[www.heated.ac.uk](http://www.heated.ac.uk)

**JISC** The Conference’s science IT stream and keynote was enabled by the support of JISC, the body providing IT assistance to universities and colleges, via the University of Bradford’s DELTA and Green IT for Science projects.

[www.jisc.ac.uk](http://www.jisc.ac.uk)
4. The S-Lab Awards - Winning, Commended and Shortlisted Applications

The first stage of the 2012 Awards involved a short application form, and resulted in the 28 shortlisted entries that are profiled in the following pages, based on information provided by the applicants. More detailed applications were submitted to a second stage, and the winning and highly commended entries were selected from these in a meeting kindly hosted by the Institute of Cancer Research in London. To avoid conflict of interest, entries were not accepted from the University of Bradford (which hosts the S-Lab initiative), or from any bodies associated with HOK (the Platinum sponsors). We are most grateful to the named individuals and organisations for their assistance with the judging. The closing date for entries to the 2013 Awards is January 28, and winning and commended entries will be announced at the 2013 Conference. This will be held at the Central Teaching Hub - which contains the Central Teaching Laboratory that is featured on p.20 - at the University of Liverpool on June 18-19.

Awards Judges

Association of Research Managers and Administrators (ARMA - Andrew Chamberlain)
Association of University Directors of Estates (AUDE - Roger Bond)
BRE Global (Sarah McCarrick)
Environmental Association for Universities and Colleges (EAUC - David Somervell and Martin Wiles)
Forum for the Future (Martin Bennett)
Health Protection Agency (HPA - Steve Owens)
HEaTED (Rachel Crossley)
Higher Education Funding Council for England (HEFCE - Joanna Simpson)
Higher Education Funding Council for Wales (HEFCW - Chris Cowburn)
HOK (Colin Gilmore Merchant)
Institute of Cancer Research (ICR - Alan Cumber)
Institute of Science and Technology (IST - Terry Croft)
London Higher (Paresh Shah)
London Universities Purchasing Consortium (LUPC - Darran Whatley)
National Association of Biochemistry and Biological Sciences (NABBS - Audra Jones)
National HE STEM Programme (Kerry Baker, Michael Grove and Nazira Karodia)
National Science Learning Centre (Mark Langley and Simon Quinnell)
Research Councils UK (RCUK - Martin Hayles)
Royal Society of Chemistry (RSC - David Barr)
Science Council (Alistair Orr)
Society of Biology (Jon Scott)
Sustainable Procurement Centre of Excellence (SPCE - Janine Hamilton)
In 3 years we’ve spent £450,000 on actions that have already delivered savings of £577,000, and which should save millions over the next decade when extended to other buildings. They’ve also avoided around 3,500 tonnes of CO₂ emissions.”

Judges’ Comments on the Laboratory Environmental Improvement Category

“Laboratories have a heavy environmental footprint, a large component of which is the energy used for moving and conditioning ventilation air. S-Lab research has shown that this accounts for around 60% of chemistry lab energy costs, and 45% of life sciences. All the shortlisted applications highlight the many opportunities to reduce this, as well as other environmental impacts such as resource consumption and waste. They also show how important co-operation between Estates, lab technical staff and other stakeholders is in achieving this potential.”

“Cross-departmental collaboration has been especially important in Imperial’s Continuous Commissioning programme. This is impressive for its embedding of continuous improvement through a management process, and for the quantitative data which it uses to identify the most cost-effective targets, and to provide evidence of success. We feel that schemes of this kind could have a big impact on HE, and that Imperial is showing the way in how to do it.”
A £2.5 million refurbishment was aimed at creating a high quality learning environment with a ‘wow’ factor. It increases the number of available fume cupboards from 32 to 41, and student occupancy by 30%, whilst emitting 80% less carbon and using £50,000 a year less energy than the previous facilities. A key factor in achieving this is VAV fume cupboards whose air flow rates vary from 2.65 to 11.50 m³/sec, depending on how many people are using them. An audible alarm system identifies any sashes that have been left open, thereby improving student awareness of good laboratory practice. Any problems detected by the BMS result in a text message to Estates and laboratory technical staff. Other features include use of heat from the University’s CHP system; heat recovery; night setback; an energy efficient lighting system; and monitors that display extract volumes and sash opening percentages to raise staff and student awareness of energy usage and further encourage sash closure. All the energy features were underpinned by detailed modeling of occupancy and use of the lab at different times and periods through the year. The refurbished labs have been praised by staff, students and sector leaders such as HEFCE CEO, Sir Alan Langlands, who noted Warwick’s “superb teaching facilities in Chemistry.”
Financial and environmental challenges, and Research Council pressure, means that science equipment has to be better utilised. Kit-Catalogue™ has shown that this can be achieved, in ways that benefit research as well as reducing costs and waste.”

Judges’ Comments on the Equipment and Services Category

“Increasing the utilisation and reuse of equipment and resources is one of the most effective and straightforward ways of improving laboratory effectiveness and reducing environmental impacts. The University of Loughborough’s Kit-Catalogue™ scheme shows what can be achieved simply by providing better information about equipment availability, and is already being taken up by other institutions.”

“Plymouth University and the University of Manchester show the potential for shared equipment use and services, and the ways in which this can facilitate collaboration both internally, and with external bodies. They also show the commitment that is needed to overcome the barriers to achieving this potential.”
Energy Use and Ventilation in Laboratories

A presentation by Paul Hasley of the University of Cambridge and Malcolm Tait of K.J. Tait noted that the University's Chemistry Laboratory has an energy bill of around £1.2 million. Another by Nigel Lenegan of Energy and Carbon Reduction Solutions, who did much of the detailed work for S-Lab's energy audits of five laboratories, noted that “moving and conditioning ventilation air, and equipment use, accounted for around 60% and 15% respectively of total energy in chemistry labs, and 45% and 25% in life science. Measures to reduce ventilation energy that were highlighted in his and other Conference presentations included:

- Reducing peak air movements e.g. through smaller and/or sectioned (so that just part can be opened) combination sash apertures; provision of ventilated storage so that fume cupboards are not used for this purpose; minimising volumes to be ventilated by area zoning or isolators (thereby reducing or avoiding the need to ventilate complete rooms).

- Making ventilation more appropriate to requirements e.g. by modifying the temperature and humidity requirements of either entire buildings, or parts of them; installing variable air volume (VAV) fume cupboards; reducing flows at night; automatic closure of sashes and/or reducing air flows when sensors indicate that cupboards are not in use.

- Making ventilation systems more efficient through measures such as reducing duct air velocities and low pressure drop design; variable speed drives on fans, and heat recovery.

Plymouth University - Equipment Sharing in the Systems Biology Centre

A recent refurbishment of the Davy Building created the 215m² Systems Biology Centre, with 10 laboratories and a Histology suite, and the latest Proteomics, Post-Genomics and DNA equipment. The initial core user is the Centre for Research in Translational Biomedicine but the Centre is regarded as a common resource, initially for the School of Biomedical and Biological Sciences and in future for the proposed Medical and Dental Schools, and commercial customers. The business case assumes that income from the latter will cover a significant proportion of running costs. The Centre has already improved lab utilisation and efficiency, for both technical and research staff. Research is able to continue uninterrupted literally 24/7 if required and all teaching can continue in the adjacent laboratory as timetabled. The Histology technician is also able to remain in a single laboratory for much of his working time, thus supporting (and ‘policing’) researchers involved in this work. Peter Russell, School Technical Manager, believes that “users involved in this newly refurbished laboratory are very pleased with their enhanced working environment and are utilising the new facility and equipment to its potential. This is increasing synergies between individuals and research groups, and we expect this to develop and prosper in the future.”

University of Manchester - Core Support Services for Life Sciences

A key design concept of the University’s Michael Smith Building, which opened in 2004, was ‘skybridges’ to adjacent buildings housing life sciences and medicine research and teaching. These were added in 2008 and enabled delivery of Core Central Services (CCS) to all the Life Sciences Faculty. CCS now includes autoclaving, equipment servicing and PAT testing, glassware washing, a ‘Media Kitchen’ to produce fly food, and stores. One example of benefit is central autoclaving which can be operated on very high loadings and allowed the phasing out of at least 10 local units. Plans are now progressing to expand CCS delivery to Faculty of Medicine researchers occupying bridge-linked buildings, and others within an Oxford Road ‘Biomedical Corridor’. This includes central provision of centrifuges, which in addition to increasing utilisation levels ensures - by requiring a swipe of staff identity cards to enable use - that users are well trained, and provides a record of use in case of any problems. A new protein expression service is also saving researchers time and resource by providing specialised guidance. CCS Manager Rita Newbould (pictured) notes that “even if the cost benefits are clear, many researchers will resist shared services because of concerns about purity, reliability etc. You must persevere, and build a trusting relationship with them, to succeed”.

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- Making ventilation systems more efficient through measures such as reducing duct air velocities and low pressure drop design; variable speed drives on fans, and heat recovery.
Our experience shows that ISO 9001 can be implemented in laboratories, with benefits for staff, students and scientific discovery. The keys to success are targeting the right activities, a cross-functional team, and senior management support.”

The University’s refurbished environmental chemistry labs now have an ISO 9001 accredited quality management system. This ensures that activities such as experiment design, staff and student training, and standard operating procedures (SOPs) are in compliance with requirements, and are improved wherever possible. Training is recognised through a multi-level Competency Matrix that allows students to broaden and document their skills in a manner that resonates with employers.

Manuals have been prepared for the operation of each instrument, with protocols for sample preparation, pre-treatments, analysis and verification, based on international standards and inter-laboratory calibrations. The movement of any sample through the system is also completely traceable.

Dr. Mike Foulkes, Senior Lecturer in Analytical Chemistry, and ISO 9001 champion, explains that “we noted that all top, commercially-oriented laboratories have or require a standardised quality system and that employers value personnel with knowledge of, and trained within, a recognised standard quality-assured system, and felt that one could benefit us. We looked at schemes such as CLAS, GLP and MHRA but concluded that ISO was best able to cover both research and teaching. Gaining ISO 9001 also helped us to introduce an ISO 14001 compliant environmental management system, which in turn has helped us to cut energy and resource consumption”.

Steve Hill, Professor of Analytical Chemistry, believes that “Mike was the driver of the system’s introduction and accreditation in 2007, and has since worked tirelessly to ensure its effectiveness and to extend it to additional areas, such as electron microscopy. We’re now seeing multiple benefits, such as more efficient laboratory operation, improved safety, increased student employability, more contract work and enhanced research. An important discovery about nuclear graphite, based on discrepancies between two of the ISO 9001 accredited instruments, would have been discarded had not the devices just been calibrated to primary standards as per their ISO maintenance schedules”.

Judges’ Comments on the Making a Difference Category

“All the applications highlight how individual actions by a variety of people can make a big difference to laboratory performance. They also show that many jobholders are willing to give energy and commitment to improvement actions well beyond their formal tasks and roles. We are also very conscious that the applications we have seen are just the tip of an iceberg of similar activity in every institution, and hope that more people will apply for this category next year.”

“The role of Dr. Mike Foulkes in implementing the ISO 9001 quality management system in labs at Plymouth University is especially impressive because of the far reaching impacts of the system, and the very positive benefits that it has achieved, not only in day-to-day operation and external reputation but the personal development of staff and students. The project demonstrates careful planning, diplomatic action, and above all great dedication and drive from its champion.”
(Individuals) Making a Difference (Highly Commended)

**Professor Andrea Sella (University College, London) and Water Saving in Chemistry**

UCL’s Chemistry Department has reduced its daily water consumption from 170 to less than 50m³, with a financial saving of over £40,000 a year. This has been achieved by recirculating cooling water used in reflux and distillation, and installing flow meters with integral control valves on equipment requiring greater volumes of cooling water. The hardware for this was simple and cost only £3,300, giving a payback of under a month. Tony Overbury, a Sustainability Manager at UCL, believes that “these astonishing savings have only been achieved because of Andrea’s leadership. His persistence in the face of inertia and his ability to choose a communication style that is best suited to his audience, whether an individual or a group, attracted the attention required to initiate the programme of water meter readings by Estates. He then utilised the data to secure senior management commitment for action, and to trigger behaviour changes by colleagues. Andrea’s approach shows the potential for academics to take a lead in laboratory environmental improvement and forge productive relationships with their Estates colleagues.”

(Individuals) Making a Difference (Shortlisted)

**Dr. Arthur Nicholas (University of Manchester) and a Sustainable Laboratories Initiative**

The University has ambitious environmental goals, including carbon emissions in 2020 that are 40% lower than in 2007/8. In 2010 Professor Maynard Case, then Associate VP for Compliance, Risk and Sustainability, asked Arthur Nicholas to convene a sustainable laboratories group to help achieve the goals in STEM areas. This now meets quarterly, and comprises senior academic staff, plus Lab and Technical Service Managers from each of the three science and technology faculties. Estates and H&S professionals are also represented at each meeting. One core activity has been piloting the S-Lab/Green Impact laboratory environmental assessment framework, with the aim of rolling it out more generally. To build capacity and develop best practice, each pilot assessment was undertaken by 5-8 technical staff from different faculties. Maynard Case believes that “Arthur’s experience in laboratory management, health and safety, and building services, plus his personal commitment and drive, enabled him to initiate and develop constructive partner dialogue, and to create a vibrant forum for sharing experience and identifying improvement opportunities. I’m sure that it will create significant benefits in laboratory energy and resource efficiency in coming years”.

**John Smith (University of St Andrews) and Laboratory Environmental Innovation**

John Smith is the Building Manager of four St Andrews science buildings, including the BREEAM Excellent Medical Sciences Building and BREEAM Outstanding Biomedical Science Research Complex (BSRC - see p.22). Energy Manager David Stutchfield believes that “our buildings, and especially the BSRC, set a new sector benchmark for energy efficiency and low carbon in laboratories. The key to this was embedding the ideas and their technical implementation into design and use. Too many schemes are circumvented by staff and students because they are in conflict with their mode of operation. Good partnership between them, designers and other stakeholders is essential and John went well beyond the call of duty in the energy and time he devoted to achieving this. He also worked with our fume cupboard supplier to design, and gain approval for, a heat reclaim system on their extract, thereby saving energy both for us and the future customers they are likely to reach. As with the automatic sash closure that we’ve also installed, John’s chemistry background, personal skills, and the respect he has from academics and Estates, enabled him to assess what was practical, and then to persuade doubters to accept it.”
The CTL is changing laboratory teaching, and technical working practices, to deliver higher quality, and more space-efficient, learning.”
Professor Paul Nolan

The 7,860m² CTL cost £23 million to build, and contains £5.6 million of teaching equipment. It consolidates most undergraduate teaching within the Faculty of Science and Engineering and is linked to adjacent, refurbished, lecture theatres and seminar rooms to form a Central Teaching Hub.

The CTL has driven curriculum redesign, with relevant disciplines making use of common skills modules, supported by degree-specific lectures. The impact has been especially great in Physics, where first and second year students now have 30-50% more practical work. This compensates for the reducing amount of this in schools and creates greater continuity with third year work. The CTL curriculum changes have been co-ordinated by a senior academic lead, Professor Paul Nolan, supported by three new Lecturer posts in the core areas of Chemistry, Physics and Environmental Sciences/Archaeology.

These changes should enable a utilisation rate of around 48% - compared to a University average of around 20%. There will also be more sharing of equipment such as gas chromatography, X-ray systems and microscopes. Despite a 35% increase in relevant student numbers, the CTL requires no additional technical support. This is due to more multiskilling and adoption of a two-shift pattern with slightly longer term-time hours compensated by more leave during vacations.

The building has a BREEAM Excellent rating. Relevant features include a steel frame, with deep precast concrete beams to provide thermal mass; floor plates and an atrium that are designed to maximise daylight; use of the University's district heating system, and solar collectors. Extensive heat recovery and air recirculation systems will also contribute to a highly energy-efficient building when some technical issues have been overcome and the building is fully commissioned.

Phillip Woodward, CTL Project Manager, believes that “close and continued involvement of users in specification and design has delivered a building which is functionally and aesthetically effective and has ensured that the opportunities for shared use of resources are maximised. A strong academic champion was essential to ensure academic buy-in”.

Judges’ Comments on the New Laboratory Building Category

“All the shortlisted entries demonstrate good practice in designing ‘fit for purpose’ laboratories for future conditions. They are adaptable, and lean in build, operation and environmental footprint, with high levels of space utilisation and equipment sharing. High levels of natural lighting and ventilation, and open spaces with good sightlines, enhance well being, and make science activities visible to other users and, often, passers by.

The University of Liverpool’s CTL demonstrates all these features and should enhance the student experience in a highly efficient way with its large, multi-purpose, teaching facilities. It also stands out for rethinking of both teaching practice and technical support, achieved not only through routine stakeholder consultation but by creating academic champions and new teaching roles. If the building’s ambitions are achieved in practice, it will be a benchmark for future sector laboratories.”
New Laboratory Building (Shortlisted)

Newcastle University - Baddiley-Clarke Building

The building combines a listed historic structure with a new one housing 3,000m² of laboratory space for the Centre for Bacteriological Cell Biology (CBCB), linked by 800m² of social and learning space at ground level. It has achieved BREEAM Excellent with a construction cost (of £2,800 per m²) similar to previous lab buildings that did not achieve it. The lab building has a ‘terraced’ arrangement of write up areas extending across the laboratory levels. An external glass wall provides good natural lighting both to them and (via an internal glass wall) to the science spaces. A central stair connects all levels and provides excellent views into the lab areas. The resulting open and airy feel, and good visual connection between the different levels and areas, achieves the key objectives of quality workspace to attract science high flyers, and cross-fertilisation between different research groups. The building was procured through a two stage design and build process, with the architects being novated to the successful contractor. Professor Jeff Errington believes that “the CBCB is the world’s first major research centre with a focus on bacterial cells. Our bright and attractive layout allows staff to be adjacent to their labs and, at the same time, close to other colleagues. This enables and encourages very positive intellectual interactions”.

Queen’s University, Belfast - Health Sciences Building

This 4,334m² building houses a Centre for Infection and Immunity which brings together three different disciplines - Microbiology, Respiratory Medicine and Immunology - which were previously at different locations. Its situation on a ‘Health Sciences Campus’ also enables broader interaction, for example with the adjacent Belfast City Hospital. Key features include a central atrium to maximise natural lighting; large walk-in cold rooms; a central autoclaving, sterilising, glass washing and media preparation room; a central store and procurement office; and improved access for disabled staff and students. Energy and sustainability features include condensing boiler plant, heat recovery, rainwater harvesting, solar thermal heating and variable speed fans and motor control. A sophisticated BMS also permits the isolation and maintenance of various micro-environments within the building including pressure regimes, mechanical air intake/extract, 24/7 air conditioning (where required) and heating boosters. Conor Kilgallen, Estates Manager, believes that: “The new facilities provide a stimulating and high quality environment to promote cutting edge research work and the future recruitment of top calibre staff. Sharing key pieces of research equipment also means higher utilisation, less time wasted by researchers in travel, and reduced risk of sample contamination during transport”.

Royal Veterinary College - New Teaching and Research Centre (TaRC)

A 1,770m² building, built at a cost of £3,100 per m², combines a reception/social/ hotdesking entrance block with research and teaching laboratories. To enable resizing, and use for either research or teaching, all labs are Cat 2, and are designed to a standard grid layout. The TaRC forms a prominent gateway to the Hawkshead campus, and its open design - with direct views into all labs - embodies the College’s aims of creating greater cross-fertilisation between its various research activities, making them more visible to students (so that more consider it as a career), and bringing more research into the curriculum. Lyn Griffiths, RVC Senior Laboratory Manager, sees “an increasing divergence between the researchers and the teachers, and a growing geographical separation between their working area. I think that this has led to courses that are more ‘teaching about’ rather than ‘teaching for’ science. We want our graduates to be adaptive experts, and individual research projects are an integral part of our degree programmes. The labs have also driven a change in culture, encouraging users to think what they actually need to carry out research, and fostering better housekeeping and management”.

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New Laboratory Building (Shortlisted)

University of Central Lancashire (UCLAN) - J.B. Firth Building

A £12.5 million, 4,000m², facility provides research and teaching facilities for the Schools of Forensic and Investigative Sciences (FIS) and Pharmacy and Pharmaceutical Sciences (PAPS). The ground floor houses a shared analytical suite, with nine laboratories with specialist equipment and a dedicated sample preparation area. Above these are two floors of large teaching laboratories, with a top floor housing chemistry and fire and explosion studies labs. These are stacked around a central atrium with a central spine of risers. This creates good visibility within the building and, together with high use of natural ventilation, creates an open, airy feel. Medical gases are stored in an external ventilated, store and fed into the risers through a ground floor 'service spine'. Optimised location of low velocity fume cupboards requires only a single extract flue for the whole building. This and other measures such as materials selection, Brise Soliel shading, and greywater use have achieved a BREEAM Excellent rating. Principal Lecturer Gary Bond believes that “good stakeholder consultation has helped us to achieve a building with high utilisation; the flexibility to teach different group sizes; access to better equipment and services; and supportive of the more autonomous, project-based, and IT/AV enhanced, learning approaches that students now expect”.

University of St Andrews - Biomedical Science Research Complex (BSRC)

The 3,584m² BSRC has a build cost of £2137, and a services cost of £841, per m². It embodies a research vision of a multi-disciplinary approach to human health and infectious disease problems which is attractive to industry as well as academic funders. This requires adaptable space to allow changes in focus - achieved through a 3.3m modular grid, vertical service risers on the building periphery, and horizontal service runs kept within the floors they serve. The labs and offices are all positioned along window walls and there is zoning of areas with different environmental requirements. The BSRC is the first building in Scotland, and the first laboratory anywhere, to achieve BREEAM Outstanding, with features such as naturally ventilated offices and write-up spaces; seasonal ‘free cooling’ to lab areas; a high efficiency variable speed chiller; CHP with excess heat transfer to an adjoining building; summer shading through building positioning and brise soleil; PIR lighting controls with daylight linking; and seasonal commissioning. BSRC Director Professor James Naismith believes that “the design shows that state of the art facilities can be achieved even in challenging times. This requires setting ambitious goals, having academic, Estates and technical support champions working closely together, and maximising space for science rather than more peripheral activities”.

The National Science Learning Centre (NSLC) - Conference Venue and Schools Advisor

The NSLC is a purpose-built facility based at the University of York which provides continuing professional development for science teachers in UK schools and colleges. It is run by the White Rose Consortium of Leeds, Sheffield, Sheffield Hallam and York Universities through Myscience (which also runs the HEaTED scheme for professional development of HE technical staff).

An important aspect of the NSLC’s work is providing laboratory design advice to schools and colleges and its experts, Mark Langley and Simon Quinnell, were instrumental in establishing and judging the Schools category of the S-Lab Awards. Mark notes that: “School and college science is increasingly based on IT-enabled learning and group work. Students also do much work on open benches, with definite times to do things, and no responsibility for equipment. University courses based on individual working, with remote demonstrators or lecturers, and requirements for clearing up, or safety procedures, can therefore be a big shock. It’s really important that academics understand the changes taking place in schools and colleges, not only so that they can adapt but also because I think that some of the practices could be adopted in universities”.
Refurbished Laboratory (Winner)
Sheffield Hallam University - Cell Culture Teaching Laboratory

£250,000 has been spent to convert 66m² office and storage space into a mammalian cell culture teaching laboratory. Dr. Susan Laird, Head of Biosciences, explains that “student numbers have been growing but our facilities were old and cramped. We were conscious of the importance of the student experience and the National Student Satisfaction Survey, and that working in state of the art specialist facilities is very helpful to student employability. Our spec was therefore for a facility with similar or better quality than commercial research environments”.

Senior Technical Officer Susan Campbell notes that “the design was based on thorough consultation. Academic and technical staff users initially selected an optimal class size of 12. Subsequent sessions brought in Estates, architects and engineers, and used CAD to optimise teaching and learning features whilst addressing building and room limitations, and compliance with environmental and fume cupboard safety standards.” The result is a single teaching area housing six laminar flow hoods (one a demonstration unit with glass sides), eight CO₂ incubators, bench space for equipment such as microscopes and centrifuges, and cupboards for plastic consumables. The room layout allows staff to easily refer to a whiteboard and the demonstration hood allows student groups to observe manipulations of cells. Flexibility is enhanced through high level data points and plug sockets for easy repositioning of equipment and furniture.

An entrance lobby area provides storage for personal items and lab coats (special blue ones to signal that students are entering a tissue culture clean area with different operating requirements to the main lab), hand wash sinks, and a sluice sink (with valves to prevent back siphoning and any risk of contaminating the main water supply). This raises awareness of waste and limits any transportation (and possible contamination risk) to other disposal facilities. Solid waste is segregated into general (black and grey bins) and clinical (yellow bins) streams with students briefed to minimise the latter. Accessibility is achieved through wide door spaces to allow wheelchair entry, push operated taps on the lobby sinks, and a mobile low level desk unit. Other features include high efficiency DC motors in biological safety cabinets; low energy incubators with a CO₂ detection system to monitor any accidental releases; slim-line, energy-efficient fridges and freezers; and ventilation systems that vary depending on lab use.

“Sheffield Hallam’s approach is academic led practicals with low staff: student ratios in industry quality lab environments.”
Dr. Susan Laird

Judges’ Comments on the Refurbished Laboratory Category

“There’s likely to be more lab refurbishment than new build in future. It’s therefore encouraging that all the shortlisted applications showed how attention to detail, user engagement, and incorporation of new technologies and approaches can create win-win benefits. These include enhanced learning, more inter-disciplinary collaboration, improved space efficiency and safety, and a lower environmental footprint compared to previous facilities.”

“Sheffield Hallam’s Cell Culture Teaching Laboratory is an extremely well designed facility that wouldn’t be out of place in a pharmaceutical company. We were especially impressed with the extensive consultation with users; the efforts made to ensure accessibility for all; and the linking of good environmental and safety practice.”
Refurbished Laboratory (Shortlisted)

Aston University - Chemical Engineering and Applied Chemistry (CEAC) Laboratory

Two smaller CEAC labs have been replaced by a single 70 person one in the University’s refurbished main building and form part of a consolidated School of Engineering and Applied Science. The new lab has 17 x 2 person fume cupboards plus a new preparation room and associated spectroscopy suite, and uses around 50% less space per student. It has enabled a greater number of more challenging experiments per lab course and better interdisciplinary knowledge and skills through increased contact between chemists and chemical engineers, and between both groups and other disciplines. This has aided student recruitment and enhanced graduate employability. The new facilities have also provided better facilities for PhDs and Post Docs and supported outreach, e.g. through schools master classes. Innovative safety features include external screened blast proof storage for gas cylinders, Drager gas detection systems, a smart fire alarm system (creating minimal disruption during minor incidents), an automatic emergency lab shutdown procedure, and remote activation of lab services to allow safe remote shutdown and structured re-commissioning after any incidents. Other features include use of CHP heating, low energy lighting and VAV fume cupboards operating at 0.4 m/s. The lab is now a model for other refurbishments at the University.

University of Kent - School of Physical Sciences

A £2.5 million refit of older facilities has provided a 100 person general physics/dry forensic science lab, an 80 person wet forensic chemistry lab, a dedicated lab for analytical instruments (previously sited over several smaller rooms), a technician office, and other facilities. The wet lab has a preparation area within it, making technical staff more visible and improving security. Moveable benches allow easier maintenance and servicing of instruments in the analytical lab, and the ability to create a large open space to hold school outreach events in the dry lab. Each lab has a video camera and large screen so that techniques can be seen by all. Brighter, more uniform, lighting has also improved viewing of practical experiments and instruments whilst reduced ambient noise allows individual conversations without disturbing others. Chemicals are stored in vented cupboards and all gas cylinders are now in an external store. Fume cupboard face velocities have been reduced from 0.5 to 0.4 m/s, and local controls and night setback have been introduced. All fans and refrigeration equipment have inverter speed controllers, and the lab has motion sensitive lighting controls. Chemistry Professor Mark Burchell (pictured) notes that “the larger labs have created 30-50% more student places without reducing per capita bench space. And feedback from both current and prospective students, and staff has been very positive”.

Leeds Metropolitan University - Biomedical Sciences Laboratory

600m² of office and classroom space was modified in under three months, at a cost of £1.1 million, to provide an open plan Biomedical Sciences laboratory for up to 106 students, with associated technical area, storage, lockers and technical staff office. The design allows simultaneous teaching of up to four different classes. Microbiology and molecular biology classes can now be taught in a single session, compared to 24 separate ones previously. Multiple displays allow sessions to be introduced by presentations and/or videos, which are made available afterwards. Dr. Biddy Unsworth (pictured left with colleagues) notes that “we’ve also received many favourable comments at Open Days and a number of students have said that the facilities were a deciding factor in their choice. Applications for the 2012/13 academic year were up by 30%, against the trend of reduced applications nationally and for the University overall. Staff have also been inspired by working together more, and have developed a much better understanding of how different course modules fit together”. Environmental improvements include segregation of fridges and incubators into separate rooms, recycling of much surplus equipment internally or to local schools, energy-efficient heat pump units and a heat reclaim system.
Schools and Colleges (Winner)
Oldham Sixth Form College - Regional Science Centre

The Regional Science Centre in Oldham (RSCO) building contains 21 high specification laboratories, and an exhibition and experimental demonstration space. The laboratories include fixed, yet flexible use, benching that allows for individual and small group work, and theory and practical, to be combined effectively without loss of space or facilities. They also have learning walls with both an interactive and a roller board; a demonstration bench for the tutor with generous space at the front for gathering students; fully plumbed services, including ports for connecting mobile fume cupboards when required; full air-conditioning and temperature regulation; and automatic light sensors.

Each floor has a designated technical/preparation area, and several laboratories have low-level benching to provide accessible worktops for wheelchair users. One laboratory is also optimised for school groups, with forward facing benching and an oval table for group work and demonstrations.

Several laboratories have floor to ceiling glass on two sides to provide an image of “science at work” for both college students and for the general public passing by. All areas are wi-fi enabled.

The Exhibition Space engages visitors on entry with displays of science work produced by College students and school pupils, and employer related material. Proximity to the school laboratory enables combined activities, with practical work being performed in the laboratory and explanations in the display area. The space can also be converted into a 150 seat lecture area with a large multi-display screen, enabling presentations and master classes from visiting speakers.

The College’s Assistant Principal, Dr. Alan Matear, notes that “our facilities are used both by our own students, and local primary and secondary schools, with over 2,800 pupils participating in 2011-12. They engage in activities that wouldn’t be possible in their schools and their teachers also benefit by working alongside our specialist tutors and mentors. The result is more uptake of GCSE and A level science subjects, and a bigger pool for the regional universities we work with to recruit from.”

Judges’ Comments on the Schools and Colleges Category
“Organisational innovation, teacher and technician enthusiasm, and the Building for the Future programme have transformed many school and college laboratories. As the shortlisted examples show, the result is more efficient and pleasant working environments, increased staff and student satisfaction, and more science students. Truro and Penwith College also shows the potential to minimise the environmental impact of teaching laboratory facilities.”

“Oldham Sixth Form College’s Regional Science Centre has been well thought out from initial planning, to delivery, through to implementation. It is particularly striking for its collaborative development at a regional scale, and the way that the design supports this by making it easy for external users to access and utilise the laboratory facilities. Its status as a satellite centre of the Manchester Metropolitan University based North-West Region Science Learning Centre also shows how FE and HE can work together effectively.”

“Increasing the level of STEM subject skills is vital for the UK’s future, and the regeneration of Oldham and the Greater Manchester area. Our collaborative approach is supporting this by encouraging more students to choose science courses.”
Canterbury College - A New Veterinary Nursing Laboratory

A new £19.5 million teaching block includes a 93m² space containing a mock surgical theatre, a dissection table, and radiography and imaging training areas. This allows the College to deliver and assess both the theoretical and practical skills which they need to meet the award requirements of the Royal College of Veterinary Surgeons and/or modern apprentice schemes. The students are able to progress their Nursing Progress Log of practical skills, including the veterinary diagnostic techniques aspect of their syllabus, without the need to use external laboratory facilities. The teaching block as a whole has achieved a BREEAM Excellent rating and the Veterinary Nursing Laboratory itself has the latest specifications for building insulation; low energy lighting schemes including automatic daylight sensors for dimming lights next to the external windows; and ventilation systems monitored by a Building Management System (BMS). The lab was designed in collaboration with both College tutors, and local employers and industry professionals. Alan Carver (pictured), Capital Projects Manager, notes that “conducting teaching within an effective recreation of a real world veterinary practice has attracted national attention as an example of good vocational training, and created a real sense of pride amongst staff and students”.

Halesowen College - New, Flexible and Smart Science Laboratories

The top floor of a new £5 million Science and IT building at Halesowen College, a Sixth Form and FE institution, houses 14 new science teaching laboratories. The laboratories follow DfES guidelines on laboratory size and space for teaching, and the CLEAPSS lab design recommendations. They provide 12% more laboratory area, and 30% more support area (with every two teaching labs having a common resource room). The core science curricula of biology, chemistry and physics each have their own technical staff. Every lab also has an electronic whiteboard, a visualiser, and a computer for each student (with a flexible positioning arm), and facilities for disabled students or wheelchair users. Additionally, storage space and work space has been increased. Science teaching staff, technical staff and science students were all involved in the design, with one result being the good facilities for preparation and storage. Dr. Adam Shaw, Faculty Manager for Health and Science, observes that “staff and student delight in the new facilities is demonstrated by a 40% increase in accepted science applications for a September 2012 start, and increased science student retention when they do arrive”.

Kendrick School - Flexibility in the New Faraday Laboratories

Kendrick School, a Reading selective school for girls aged 11-18, has two new labs which can become a single large space when required. This has enabled more large group sessions internally, and many external events not possible in other schools such as sessions to raise the profile of science with primary school pupils, and CPD training and exam board information sessions for local teacher networks. Each individual lab has a range of seating options to allow different teaching and practical arrangements. Other features include a linked outdoor science area (with drama space, greenhouse, pond, plant beds, nest box with linked webcam, weather station and chickens); a nearby ‘break out room’ for dry/ICT/discussion work; and a connecting prep room, which minimises transport of chemicals and therefore risk of accidents. Provision of two fume cupboards also increases health and safety and improves learning by reducing congestion for demonstrations, and allowing a wider range of experiments. Dr. Karen Perry, Head of Science, notes that “our new labs have enhanced teaching and learning, for example, by providing new options such as ecological work, and by making it easier to match group sizes to activities. Since they were built the A level science numbers and attainment levels have risen considerably”.

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Schools and Colleges (Highly Commended)

Truro and Penwith College - A Flexible and Green Science Laboratory

The top floor of the College’s Porthcurno building, on its Penwith campus, has new labs, a library and IT area, a refectory and a fitness suite (used by Human Biology students for cardio-vascular experiments). The labs have very high sloping ceilings, making them light and airy and allowing heat and fumes to dissipate quickly, and cantilevered windows which reduce glare. One also has a glass wall to allow visitors and students to ‘see science at work’. Water, gas, ventilation, and network points have been installed in some non-lab areas to provide future flexibility. Each lab has been tailored to lecturers’ specific requirements including room layout and benching materials/colours. The benching is portable and there is a generous allowance of 0.48m² of space for each student. Under-floor heating has significantly increased the storage facilities on walls. Wi-fi has been incorporated into the whole building and, together with a set of portable laptops, allows staff to incorporate individual or group use of ICT into lessons.

The building as a whole has a highly insulated building envelope, high levels of natural lighting and ventilation, lighting controls, brise soleil to control solar gain and energy efficient white goods. A wind turbine meets nearly 40% of total electricity needs on campus, and powers a ground source heating pump for heating in the winter, saving £19,000 in costs and 85 tonnes of CO₂ since operation commenced. Martin Tucker, Director, says that “the new facilities have increased communication between staff from different disciplines, and created closer liaison with secondary schools, for example through the College hosting science CPD meetings for teachers. Student satisfaction has also increased to over 95%, student numbers have doubled and there’s been a significant increase in applications to science based university courses”.

Teaching and Learning (Shortlisted)

University of Southampton - Virtual Experiments in Undergraduate Laboratories

The University has, with support from the National HE STEM Programme, developed several web-based applications that enable interaction with a pre-recorded experiment. Virtual Resources Development Officer, Paolo Memoli, says that these “can complement lab work by allowing students to develop or reinforce key skills such as experimental design and data handling and interpretation in their own time. When used as preparation for actual experiments they can familiarise students with the equipment and techniques involved, and raise key questions in advance, so that their actual lab time is more productive. They can provide opportunities to perform experiments which may otherwise be too expensive or dangerous”. The most successful example is a virtual diode experiment in Electrical Power Engineering, developed as students had difficulty understanding some higher level concepts from demonstrations. The application now contains the questions and prompts that would normally be provided by a demonstrator. As well as improving the level of understanding and discussion, it has been very useful for revision. In Chemistry, another virtual experiment deals with reaction chambers, as the equipment is in limited supply and often temperamental. The University has produced a good practice manual to share learning from the work.

See over for Judges’ Comments
"Integrated Chemistry teaching labs can increase space, equipment and resource utilisation, improve health and safety, and enhance student learning through better support and less switching between rooms and equipment as they progress."

Judges’ Comments on the Teaching and Learning Category

“Financial pressures are requiring more to be done with less in all areas of university life so it is encouraging to see that the University of St Andrews is achieving this in Chemistry whilst enhancing the student experience. The approach enables, and encourages, students to work with other university members of staff and gain awareness of the activities and techniques they will undertake in the later years of their degree. The model is simple but very effective and we feel that the concept should be considered by other universities when refurbishing relevant laboratory provision.”

“...In the medium-term IT is likely to transform the laboratory experience, perhaps by much greater use of virtual experiments. There may remain many questions as to the best way to utilise such activities, and the impact on student practical skills and employability, the University of Southampton is to be commended for its pioneering work on the topic.”
5. S-Lab Publications and Activities

Guidance

Briefing papers on:
1. Interest-free Funding for Energy Efficient Labs.
2. Understanding Laboratory Energy Consumption.
3. Laboratory Environmental Assessment.
4. Effective and Energy Efficient Cold Storage.
5. Reducing Water Consumption in Laboratories.
7. Strategic Approaches to Sustainable Labs.

Other publications include:
2. The Impact of Building Design on Laboratory Performance - AstraZeneca’s Etherow Building.
4. Financing Energy Efficiency in Labs and Data Centres.
5. Greening STEM Curricula.
6. Demand Related Ventilation.
7. Sustainable Laboratories - Energy Benchmark Data.

Assessment and Audit

Laboratory Energy Auditing - a detailed study of consumption at three life science and two chemistry labs at Cambridge, Edinburgh, Liverpool, Manchester and York Universities plus a ‘How To’ Guide.
Laboratory Environmental Assessment Framework (incorporated into the NUS Green Impact Scheme) and associated Laboratory Environmental Good Practice Guide.
Laboratory Credits developed for BREEAM.
IT Carbon and Energy Footprinting Tool - developed by our sister SusteIT project.

Good Practice Cases

These cover many aspects of laboratory design and operations at Belfast, Bradford, Cambridge, Edinburgh, Manchester, Newcastle, Nottingham, Oxford, Queen Mary, and York Universities, plus AstraZeneca, Imperial College, Stanford and the University of California.

Communities of Practice

Newsletter to over 1,400 subscribers and as many attendees at 40+ events on all aspects of laboratory design, operation and use. Most presentations from the latter (and from the 2012 Conference) are available via www.goodcampus.org.

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BEST PRACTICE

Images clockwise: 1) Engaging presentations; 2) Some of the University of Liverpool’s award-winning CTL team - Geoff Dickinson, Dr. Lee Reilly and Phillip Woodward; 3) Dr. Katherine Forsey, HEATED, explaining the importance of professional development for technical staff.

Left: Bradford’s HE STEM team - Dr. Peter Hopkinson, Gayle Dickson, Helen Tobrah, Dr. Lou Comerford Boyes, Dr. Nazira Karodia and Professor Richard Greene.

Right: The HOK team - Colin Gilmore Merchant, David King, Briany Lumb, Bill Odell and Randy Kray

NETWORKING

Clockwise: 1) Intense discussions over coffee; 2) Creating Scottish connections - Alaine Martin and Dean Drobot (Strathclyde) with John Smith (St Andrews); 3-5) Sponsors Richard Barringtin, Iceotope, John McAuley (FMS), and Chris Mulholland (Critical Airflow) explain their products.

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