Bristol ChemLabS CETL Final Report to HEFCE

PART ONE – STATISTICAL INFORMATION

a. Name of CETL

Bristol ChemLabS (**Bristol Chem**ical **Lab**oratory **S**ciences)

b. Name of Institutions(s)

The University of Bristol

c. Contact name (someone likely to be in post until July 2010)

Professor N C Norman, ChemLabS Chief Executive

d. Name of person submitting the self-evaluation

Professor N C Norman, ChemLabS Chief Executive

e. Start date of CETL

1 April 2005

f. Anticipated end date of CETL (if known, i.e. will it end with the money, when, will it continue in some recognisable form?)

Recurrent CETL funding will cease on 31 March 2010. All other aspects of the ChemLabS programme will continue.

g. Lead Director(s) and dates associated with CETL

Professor N C Norman, ChemLabS Chief Executive since the start of the CETL programme.

h. Total amount of award: capital and running

The initial award to Bristol ChemLabS was for £2.5m in recurrent funding and £2m for capital projects (the maximum amount which could be bid for). Later in 2005, HEFCE announced that additional CETL capital funds were available and that CETLs could submit bids for up to £350k. In December 2005, Bristol ChemLabS and AIMS (the other CETL at the University of Bristol) submitted a joint bid for £700k for additional capital projects, together with a request for further funds should these become available. In February 2006, notification was received from HEFCE that the bid for £700k had been successful and in April 2006, HEFCE acceded to a request for a further £335k for capital funding, £167.5k for each CETL. The total capital grant to Bristol ChemLabS was therefore £2m + £350k + £167.5k = £2.5175m.

i. Briefly describe what the capital was used for (e.g. refurbishment of three small group teaching rooms and small lecture theatre; building of office and informal social/learning space for students)

The £2m capital grant was used, together with a substantial University of Bristol contribution amounting to around £14m, to completely refurbish and re-equip the teaching laboratories of the School of Chemistry on two floors in the School's West Block (some of the £14m UoB contribution was used for other aspects of the West Block refurbishment). The additional HEFCE capital funds were used to establish additional teaching space by refurbishing existing areas between the West and South, and South and East Blocks of the School of Chemistry as well as enabling in-fill building projects for social space in the area between West and South Blocks.

j. What will these facilities be used for in academic year 2010-11? (indicative/anticipated)

All ChemLabS facilities will continue to be used for laboratory teaching and for teaching support. With regard to the laboratory space itself, the facilities are used intensively during undergraduate term time. When undergraduates are not present, the labs are used to support Outreach activities, including teacher CPD courses, and training courses for industry.

k. Average number over lifetime of the CETL of persons employed at any one time, in FTEs and by type: academic, admin, other (please indicate type of job)

- ChemLabS Manager, academic, 3.3 FTE
- ChemLabS School Teacher Fellow, academic, 4.7 FTE
- ChemLabS Teaching Laboratory Managers, academic, 4.7 FTE
- ChemLabS Technical Support, technical, 1.0 FTE
- ChemLabS Secretary, clerical, 4.0 FTE
- ChemLabS Research Support for CEO, Director, Outreach Director and University Teacher Fellow, academic support, 8.8 FTE

l. What are staff employed by the CETL towards the end of its HEFCE funded life going to do when this funding ends? Summarise, do not name staff, e.g. 2 part time academic staff return full time to university role; centre administrator has job in private sector lined up; research officer has an academic appointment for 2010-11 in another university; learning technologist will remain employed by host faculty to continue with similar work; not yet clear for 1 staff member)

The ChemLabS Manager, Teaching Laboratory Managers and Technical Staff will remain employed by the School of Chemistry and will retain their ChemLabS responsibilities. The Research Support posts for the ChemLabS CEO and Director employed research staff on fixed-term contracts who have now left. The first ChemLabS University Teacher Fellow is and will remain an academic member of staff in the School of Chemistry and the second person appointed to this post will remain in the Department of Biochemistry. The ChemLabS Secretary has moved to other employment in the University of Bristol and secretarial duties are being carried out by another member of the School of Chemistry secretarial team. The School Teacher Fellow will be self-funded from the Outreach Programme, alumni funds and other commercial activities.

m. Number of 'spin out' projects funded: List projects by title and amount awarded, and name institution if other than host.

eBioLabs, JISC, £200k, Department of Biochemistry, UoB. eBioLabs is refered to in more detail in the answer to Question 10.

In addition to this formal 'spin out', Bristol ChemlabS has generated multiple commercial activities through the LabSkills initiative as outlined in the answer to Question 4.

n. Number of peer reviewed outputs published that relate to CETL work – list in Annex A.

For a full list of Reports and Publications, see http://www.chemlabs.bris.ac.uk/Publications.html. Of the Outreach publications, >35 were peer reviewed.

i. If you wish, list up to 5 other outputs that have not been peer reviewed

All publications resulting from ChemLabS activities are listed on the ChemLabS website, see http://www.chemlabs.bris.ac.uk/Publications.html.

o. Number of events held to develop or disseminate work beyond the CETL in the last three years internally; externally. Please also draw attention by means of a short paragraph each to 3-5 events that have been especially important or noteworthy, e.g. title, date, size, type of attendees, purpose, why it was important.

- Bristol ChemLabS Stakeholders Conference, May 2005
- Presentation to UoB Court, December 2006
- Presentation to Stakeholders and Opening Ceremony, November 2007
- Presentation to Heads of Chemistry UK, November 2007
- Alumni Day, September 2008
- Presentation to the Working Group Meeting of the Sector Social Dialogue Committee of the European Chemical Industry, December 2008
- Bristol ChemLabS Dissemination Conference, April 2009
- Presentations to universities in South Africa, Singapore, Malaysia, Brunei, Thailand, Australia,

Kuwait, Spain, Malta and Ireland by the CEO and/or STF since 2008

- Presentations to universities in the UK (Edinburgh, 26 May 2009; UCL, 19 June 2009) by the ChemLabS Director
- Presentations at international events (EuroVariety conference, University of Manchester, 4 September 2009)

The single most important event would be the Bristol ChemLabS Dissemination Conference, details of which can be found at http://www.chemlabs.bris.ac.uk/Dissemination-Conference.html.

p. If any appropriately experienced member of your CETL team wishes to participate in a peer review scheme of CETL self-evaluations, please provide their names and contact details, especially email. ***(Participation in the scheme means that you are putting your own self-evaluation up for peer review and indicating willingness to act as a peer reviewer for up to 2 other self-evaluations. These will need to be completed within a reasonable timescale, to be determined once we see how many people wish to be involved.)***

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PART TWO – EVALUATIVE REFLECTION

Question 1
Please reflect on how effective your CETL has been in contributing to the objectives set out for the CETL initiative when it started. Be concise and do not exceed 1,000 words for the whole of the question

i. To reward practice that demonstrates excellent learning outcomes for students.

The University of Bristol has recently introduced a new career structure for academic staff based around three career pathways. Pathway One applies to staff who have a contractual obligation to perform research, teaching and administration whilst Pathway Two applies to academic staff whose contractual obligations relate primarily to research. Pathway Three is for those whose responsibilities lie in teaching. All three pathways follow a similar structure, with the possibility of progression to the level of Senior Lecturer and then promotion to Reader or Professor. Transfer between the three pathways is possible, but not automatic, especially at the most senior levels. The creation of Pathway Three is an important development for a research-led university such as Bristol. The new scheme recognises the importance of such staff in delivering excellence in teaching, as well as allowing staff on Pathways One and Two to devote more time to research. By establishing a largely teaching-related career pathway that allows promotion right through to the position of Professorial Teaching Fellow, the new strategy formally values the important contribution of such staff to the University. For the first time, it places the excellence and achievements of staff engaged primarily in teaching on a par with those engaged primarily in research.

It is difficult to determine the precise impact of the Bristol ChemLabS CETL (as well as its sister CETL AIMS) on the development of this new career structure and the creation of Pathway Three in particular. However, both CETLs have had a considerable impact within the University by raising even further the status of teaching and learning and illustrating some existing effective practice. The formal recognition by HEFCE (through the award of the two CETLs) that certain departments within the University are national leaders in delivering excellent and innovative teaching is powerful support for the development of a career strategy that rewards and recognises the staff involved appropriately. Indeed, some of the first senior promotions for staff on career Pathway Three have been made to those staff from the CETL teams, in particular Paul Wyatt, the Bristol ChemLabS Director has been promoted to reader, whilst Dudley Shallcross, the Bristol ChemLabS Outreach Director has been promoted to professor.

ii. To enable practitioners to lead and embed change by implementing approaches that address the diversity of learners' needs, the requirements of different learning contexts, the possibilities for innovation and the expectations of employers and others concerned with the quality of student learning.

Meeting the needs of a diverse cohort of students has been at the centre of the developments introduced as part of Bristol ChemLabS Programme. New undergraduate chemistry students arrive at university with very different levels of experience in practical chemistry. Some have had the opportunity to perform a lot of experimental work as part of their secondary education and are already reasonably confident in the laboratory but others are much less familiar with even the most basic experimental techniques, and require much more support. The introduction of self-study resources embedded within the Dynamic Laboratory Manual (DLM, see the answer to Questions 2 and 3) has, however, allowed students to learn at their own pace and it includes many elements, such as video clips, simulations and self-tests that appeal to different types of learner. Meeting the expectations of employers was also important in introducing our new practical courses. Employers were consulted early in the Programme, particularly in the development of new experiments, to ensure that the skills and knowledge that students develop would be appropriate for future careers. This very positive interaction has led to a practical course that is both academically rigorous and which meets the needs of employers.

The success of these innovations in meeting the challenge of developing innovative teaching and learning strategies that meet the needs of a diverse cohort of students as well as employers has now translated through to other aspects of chemistry teaching. Thus, the School of Chemistry has recently started to review the structure and content of its lecture-based courses, and is confident that similar strategies can be employed to meet the different demands in these more theoretical elements of the programmes. The CETL project has therefore given practitioners the confidence to reflect on the quality of the student experience and think creatively about implementing changes more broadly.

iii. To enable institutions to support and develop practice that encourages deeper understanding across the sector of ways of addressing students' learning effectively.

The success of both Bristol ChemLabS and AIMS as CETLs within the University of Bristol has undoubtedly raised the profile of teaching and learning within the institution and so helped to engender a culture in which members of staff are encouraged to develop a deeper understanding of the needs of students. This is reflected in developments such as the changes in the role profiles of the University's academic career structure (see *i* above), the creativity of staff in wanting to continue to innovate in areas beyond the initial remit of the CETLs, as well as the adoption of some of the new approaches introduced by the CETLs in other subject areas.

iv. To recognize and give greater prominence to clusters of excellence that are capable of influencing practice and raising the profile of teaching excellence within and beyond their institutions.

The Bristol ChemLabS Programme has had a considerable influence on best practice in teaching and learning both within the University of Bristol and beyond. The use of interactive on-line resources to help students prepare for laboratory classes has now been adopted by other departments at the University of Bristol, including Biochemistry and Physiology & Pharmacology (see answer to Question 10); other faculties and schools are following. The impact that the use of such resources has had on the effectiveness of undergraduate laboratory work has been recognized by other organizations, such as the Higher Education Academy who recommended that the DLM model should be adopted as part of a radical overhaul of the structure of first-year practical courses in the life sciences (see http://www.bioscience.heacademy.ac.uk/ftp/reports/pracworkshopreport.pdf). Moreover, the impacts have even been felt at other levels of education, with the successful introduction of Dynamic Laboratory Manuals such as A-Level LabSkills, which is aimed at secondary students, and versions for the School of Chemistry's postgraduate EPSRC-funded Doctoral Training Centres in Chemical Synthesis and Functional Nanomaterials.

v. To demonstrate collaboration and sharing of good practice and so enhance the standard of teaching and effective learning throughout the sector.

There have been a number of events where the activities of the CETL have been disseminated formally as outlined below.

The Dissemination Conference
A one-day conference about ChemLabS was held in the School of Chemistry on 2 April 2009. The 42 delegates present came from chemistry and other academic disciplines in other UK HEIs as well as from within the University of Bristol. Visitors came from Cardiff University, Glasgow Caledonian University, Harper Adams University College, Imperial College London, Loughborough University, Manchester Metropolitan University, Nottingham University, Oxford University, the HEA Physical Sciences Centre, The Open University, University College Dublin, University College London, and the Universities of Aberdeen, Bath, Birmingham, Cambridge, Leeds, Leicester, Oxford, Plymouth, Reading, Warwick and York. Feedback from the Conference was very positive and there were several queries about the software being made more widely available. The lab manager from Leicester summed up her day by saying *"…I thought the conference gave a brilliant overview, I learned a lot, and I came away feeling inspired*."

Presentations
Presentations about Bristol ChemLabS have been given at:

- Edinburgh Symposium on Chemical Education, 26 May 2009
- UCL Chemistry "Teaching and Learning Day", 19 June 2009
- EuroVariety conference, University of Manchester, 4 September 2009

Upcoming Events
A presentation about ChemLabS will be given at the 21st Biennial Conference on Chemical Education at the University of North Texas, in August 2010, and the Director of ChemLabS has been awarded an Erskine Fellowship at the University of Canterbury in New Zealand to advise on the redevelopment of their laboratory teaching of chemistry and biochemistry.

Dissemination in-house
We often have visitors in the department and take the opportunity to show them the CETL facilities which in turn has led to more formal invitations for ChemLabS staff to visit other institutions (the Erksine fellowship for example). Visitors, many from overseas, often ask to visit us specifically to

learn more about ChemLabS including the DLM, laboratory design and Outreach; staff have visited from institutions including the Universities of Utrecht, Aberdeen, Newcastle, Manchester and Warwick, University College Dublin, Imperial College London and the Open University.

vi. To raise student awareness of effectiveness in teaching and learning in order to inform student choice and maximize student performance.

The Bristol ChemLabS CETL has undoubtedly raised student awareness of effectiveness in teaching and learning. Thus, the project has been a major contributor to the significant increase in popularity of the University of Bristol amongst potential undergraduate chemistry students. Applicants have been attracted to the University of Bristol not only by the world-class practical laboratories and state-of-the-art equipment, but also by innovations in teaching and learning methods, such as the introduction of the Dynamic Laboratory Manual. As a result, both application and conversion rates have increased significantly. During the period of the CETL Programme, we have therefore moved to an enviable position for a discipline that has been considered as strategically important but vulnerable, of starting to select only from cohorts of straight A applicants. There has also been evidence of students citing the developments at Bristol ChemLabS when discussing applications with other institutions, suggesting that applicant choice may be a useful driver in improving standards across the sector.

The project has also raised awareness of the effectiveness of teaching and learning amongst existing undergraduates. One of our ambitions was to make the student experience of practical chemistry more effective, not only by the establishment of new facilities, but also through the development of new teaching, learning and assessment methods. These were intended, in part, to make students more independent and there is evidence, both from interactions with individual students and from assessment data, to show that these have not only had an impact on the performance of students within their practical courses, but also in other elements of their degree programmes.

Bristol ChemLabS has also had a significant impact on the postgraduate community in Bristol as a result of large numbers having been engaged as laboratory demonstrators and also because the DLM concept has been imported into the first year training programmes of both the Doctoral Training Centres in Chemistry; more details are provided in the answer to Question 4. Several hundred Bristol chemistry postgraduates have also been trained as STEM Ambassadors as part of Bristol ChemLabS Outreach (http://www.chemlabs.bris.ac.uk/outreach/SEAs.html).

Question 2

Please set out the aims and objectives specific to your CETL at the start; and for each one reflect how well these have been achieved. Be concise and do not exceed 1,000 words for the whole of the question.

Our ambition at the start of the CETL was to deliver a laboratory-based teaching and learning experience for chemistry undergraduates at Bristol that was second to none. As such, the ChemLabS CETL was quite subject-specific, at least initially. In the first phase this would involve the complete refurbishment of all the teaching laboratory space in the School of Chemistry using those CETL funds allocated to capital projects as a contribution to the total cost (the University of Bristol contributing the remainder). This part of the project was delivered on time and on-budget and resulted in state-of-the-art facilities that are not only fit-for-purpose but have also been completed to a very high, professional standard. In addition, all of the equipment and instrumentation with which the laboratories have been furnished is new and of a standard that is at least as good as comparable infrastructure in our research laboratories. Bristol undergraduates now have the best possible laboratory environment in which to study and learn.

Whilst the best laboratory infrastructure is essential to the delivery of an excellent practical course, what the students actually do in the laboratory is even more important. Thus, we took the opportunity to completely review all aspects of the student laboratory experience by focusing on what we actually wanted to achieve in the labs. This involved a radical overhaul of the experiments and associated practical skills training, assessment (pre- in- and post-lab) and pre-lab preparation. All of this, we envisaged, would be delivered through an online, interactive, web-based laboratory manual which would be known as the Dynamic Laboratory Manual or DLM. The DLM has not only met all of our initial expectations, it has exceeded them by a considerable degree as outlined in the answer to Question 3 below. Throughout the development phase, consultation with stakeholders was wideranging and included a Stakeholders Conference (June 2005), student focus groups run by external facilitators, and input from employers. In relation to skills training, we took the decision to

abandon the old style of having labs linked to the traditional subject specialisms, inorganic, organic and physical, and also to not make any explicit connection between the content of labs and lectures. Instead we constructed fully integrated laboratories for each of the undergraduate years 1-3, for which labs form a part of the curriculum, and focused on designing experiments which would deliver key practical skills training appropriate to that particular year group; employer engagement was sought and received in this regard. Year 1 introduces aspects of basic skills training which are developed to a higher level in Year 2; by Year 3, students are being encouraged to make the transition from being in a highly structured teaching laboratory to working in an environment more akin to a research laboratory. Evidence of the success of this approach, from the point of view of the students, in provided in the answer to Question 4. In terms of assessment, we developed pre-laboratory work for all experiments (forming part of the assessment for that experiment), in-lab assessment of practical skills for most experiments, whilst retaining post-lab assessment for only a small fraction of experiments (previously all experiments had been assessed in this manner). For the post-lab work, this comprises a structured report for which students are given detailed guidance and examples online.

We were also very much aware that our teaching laboratories would only be used for about half of the year during those times when the undergraduate students are present in Bristol. We wanted to make sure not only that this resource be available for other activities but, critically, that these other activities could be a way of raising much needed revenue as part of the long term financial sustainability plans for ChemLabS. We therefore set out to develop a comprehensive Outreach Programme for primary and secondary schools, and the wider public, as well as programmes for teacher CPD and training courses for industry. Outreach is now a very extensive activity enabled by a full-time School Teacher Fellow (see http://www.chemlabs.bris.ac.uk/outreach/) and is run according to a detailed business plan that is designed to cover all its costs on a full economic costing basis. Industry training courses are also offered and are priced at a commercial rate.

Question 3
Please add any objectives that emerged as the CETL developed, and reflect on these as for question 2 (500 words maximum).

All of the original objectives are outlined in the answer to Question 2 above, but what has now become a major objective, which was not considered initially but was quick to emerge, is the effect that the DLM is having on other aspects of the Bristol chemistry curriculum. Thus, in addition to those aspects of the DLM which we envisaged from the start (online assessment, video, virtual instruments, interactive simulations), it soon became apparent that the DLM would be an ideal host for a range of sophisticated, interactive online tutorial material designed to support student learning in areas of study related to their laboratory experience but not explicitly covered therein. Most of this material relates to details of the analytical and spectroscopic methods that the students encounter in the laboratory, an understanding of which is essential if the students are to gain the maximum benefit from their use. As ChemLabS developed, not only did this tutorial material provide a considerable degree of added value to the laboratory experience, it was also of direct value in supporting those lecture courses delivered in other parts of the curriculum. This, in turn, has led to the development of more online tutoral material being developed and planned as part of a comprehensive overhaul of the entire Bristol undergraduate chemistry curriculum which is currently being undertaken in the post CETL period.

Another objective which emerged was the importance of fundraising to support future financial sustainability. Thus, and associated with the University of Bristol 2009 Centenary fundraising campaign, ChemLabS has engaged (successfully) with industry and Bristol alumni to raise funds to support certain aspects of the programme.

Question 4
Irrespective of your answers to questions 2 and 3 above, please reflect on, and draw out the achievements and benefits of the CETL (1000 words maximum) (Think about different audiences, types of output, impact internal and externally, on professional/staff development, on student learning, work over an extended period, use of money for facilities development etc.)

First and foremost, the Bristol ChemLabS CETL has had a profound impact on the teaching and learning of practical chemistry for undergraduates in Bristol both in terms of the laboratory infrastructure and, in particular, the student experience in the laboratory. This is what we set out to do and this is what we have delivered. Other benefits for the undergraduate students have been the impact of the online tutorial material and its application to related parts of the curriculum (see answer

to Question 3 above).

Beyond its impact on Bristol undergraduates, many of the ChemLabS achievements have been disseminated through conferences and lectures (answer 1*v*), the ChemLabS website (http://www.chemlabs.bris.ac.uk/) and discussions with colleagues from other institutions both at Bristol and in other departments. Key features of the ChemLabS DLM are contained within the Foundation LabSkills DLM product (http://www.labskills.co.uk/university.php) which is available commercially both in the UK and overseas.

Bristol ChemLabS has also had a significant impact on the postgraduate community in Bristol in three ways. Firstly, a large proportion of the laboratory demonstrators are postgraduates and they have therefore had an opportunity both to teach and assess undergraduates and thereby develop their own transferable skills in this regard. Secondly, almost 400 postgraduates have been trained as STEM Ambassadors (answer 1*vi*), and thirdly, the DLM concept has been imported into the first year training programmes of both the Doctoral Training Centres in Chemistry (as outlined in the answer to Question 12) and has therefore had an impact on postgraduate training.

In terms of other disciplines, the DLM concept has been adopted by the Department of Biochemistry for its first year laboratory (see answer to Question 10), and is being adopted by the Department of Physiology and Pharmacology.

In addition to its impact on undergraduates and postgraduates, Bristol ChemLabS has, over five years, developed a schools and wider public Outreach programme of very considerable scope and volume which now engages with around 30,000 students each year. The accomplishments of ChemLabS Outreach are too numerous and extensive to detail here but they are available on the ChemLabS website at http://www.chemlabs.bris.ac.uk/outreach/. ChemLabS Outreach nows expects to run on a fully sustainable basis by charging customers at a price they can afford and with the aim of being financially self-sufficient on a full economic costing basis. The success of this programme was recognised in 2009 with the receipt of a prestigious Business in the Community 'Big Tick' Award as well as by achieving the accolade of 'Highly Commended' in the Bank of America Merrill Lynch Education category. ChemLabS Outreach has also played a significant part in helping to deliver the University of Bristol's widening participation and public engagement agendas.

Finally, Bristol ChemlabS working with Learning Science Ltd have developed the LabSkills range of DLM products to support the practical component of A-Level chemistry at student, teacher and school level as well as producing Foundation LabSkills to support practical chemistry skills development at HE level (see http://www.labskills.co.uk/). The revenue from this commercial venture will be used to support and invest in continuing ChemLabS activities.

Question 5
Have there been any disappointments in how the CETL has developed/what it has achieved. What are they, why did they happen? (600 words maximum)

No. In many respects, much of what was achieved has exceeded expectations, in particular the power and scope of the DLM and its affect on student learning and preparedness. The LabSkills products developed with Learning Science Ltd is a particularly exciting commercial venture which was not even envisaged at the start. In terms of the Outreach work undertaken, the ChemLabS School Teacher Fellow model has been so successful that it has been adopted by several other institutions.

Question 6
Please reflect on the difficult and easier aspects of getting the CETL going and of getting your messages across. For example: Has action/change followed; where and why did you meet success or resistance. What worked, how did you discover this, how do you know it worked? (1000 words maximum)

In truth there have been no aspects of delivering Bristol ChemLabS which we would describe as difficult. That is not to say that the work has not been challenging, but at the start we had a clear vision of what we wanted to achieve and after five years we feel we have delivered that vision (and more). In fact, we think that we have 'raised the bar' in terms of how best to deliver a teaching and learning environment for undergraduates in practical chemistry. This has clearly benefitted our undergraduates but through our programme of dissemination, and the commercial products we have developed, we have sought to make our work available to all. Moreover, our outreach work and the LabSkills venture with Learning Science Ltd has enabled us to bring what we have developed to a

much wider audience, most notably by supporting the teaching of practical chemistry at A-Level, and has thereby contributed significantly to key objectives associated with the national STEM agenda. Translation of ChemLabS developments into other disciplines at undergraduate level and in to postgraduate training has also been a major success.

Evaluation of all ChemLabS activities and their impact on the student experience has been carried out throughout the programme primarily by means of student focus groups (with external facilitators), questionnaires, and through the appointment of an external academic evaluator. Feedback from the student groups and questionnaires has been very positive and the external evaluator's report, by Dr Stuart Warren from the University of Cambridge, was submitted in November 2008 and is available from our website (http://www.chemlabs.bris.ac.uk/Documents/StuartWarrenReportNov08.pdf). A part of the report in relation to the DLM states: *"The most obvious point to an outside observer is the purposeful air and committed attitude of the students at all three levels. [...] The students knew what they were doing and were deeply involved in it. [...] No student at Bristol, when asked what (s)he was doing, replied 'I'm down to here on page 2.' [...] The DLM (Dynamic Laboratory Manual) is vital to the operation of the labs."*

The best evidence for student satisfaction has come from the students themselves who are the most critical of evaluators, and in the early days of ChemLabS, with new assessment procedures in place but with the DLM still to come online, students were asked what they thought. Only this one group of students experienced the 'before and after' and a Table of questions and how they scored is presented below.

Student Views before and after the ChemLabS.

Scores are on a scale of 5 to 1; lower numbers are better.

	Before ChemLabS	After ChemLabS
'I looked forward to laboratory sessions'	3.20	**2.49**
'The laboratory provided an excellent teaching environment'	3.18	**1.78**
'The assessment used (in-lab or otherwise) has been a good way to provide feedback'	3.22	**2.40**
'I was prepared in advance of the laboratory'	3.47	**2.03**

Although we were not able to ask those questions again, as students from that point had never seen the labs *before* ChemLabS, current (*ie* 2009/10 academic year) third year students are the most informed and have had the full ChemLabS experience. From questionnaire results it is clear that the students think the Year 3 laboratory in particular is a success and they were specifically asked questions about how they think the Year 3 laboratory compares with the Year 2 laboratory (the intended difference between the two labs is outlined in the answer to Question 2). For example 34% agreed or strongly agreed with the statement 'Last year, I was inspired by the chemistry I encountered in the laboratory'. But **70%** agreed or strongly agreed with the statement 'This year, I was inspired by the chemistry I encountered in the laboratory'. Before ChemLabS we would have expected only about 5% of students to agree with such a statement. We are therefore encouraged that the students themselves are so full of enthusiasm about the laboratories.

Moreover, the students feel that engagement of the staff is excellent with 76% of students agreeing with the statement that 'This year, staff demonstrators appeared to enjoy demonstrating'. This is a testament to the positive atmosphere we set out to achieve. Furthermore, 97%, agreed with the statement 'This year, the laboratory is furnished to an excellent standard'. These results therefore support our view that we have been successful in providing students with the state-of-the-art equipment, research-informed experiments and hands-on use of research-level analytical instrumentation that we set out to put in place from the outset.

Finally, students have clearly appreciated that we have set out to raise the challenge year on year. A third year student said of the laboratories *"...one of the best parts of the course in my opinion. It would have been very easy to have the labs set up such that we just learnt a few new techniques each year, but with the day to day process being much the same. As it is, it seemed there was a different emphasis to what we were learning each year, and a greater sense of self-direction and responsibility - this approach kept labs interesting and challenging."*

Question 7
Has your CETL adopted/used/been based around any specific theories, e.g. of change, or of student learning? If so, what, how have these underpinned your work, have they been useful? (1000 words maximum)

Not really. As chemistry academics responsible for constructing and delivering a curriculum in a single subject, we had a clear vision of what we thought was needed and what would work. Nevertheless, we made sure to involve groups of students in all of the development work from the very start of the Programme. This student involvement proved invaluable and offers a model for effecting major change in any educational setting (a topic often addressed by the QAA). Much of the success of the ChemLabS approach has been due to it being rooted in a single academic discipline albeit an approach which is transportable to other laboratory subjects (see answer to Question 10).

Question 8
Reflecting on the last five years what other important messages are there that you want to convey about your CETL - its successes, difficulties, impact etc. (1000 words maximum)

Have a clear and detailed vision about what you want to achieve and work hard to deliver it!

Question 9
Reflecting on the last five years what important messages are there that you want to convey about the experience of being part of a wider 'movement'/experience of other CETLs. (600 words maximum)

Bristol ChemLabS is almost unique in being coordinated by a single university department, focusing on one aspect of a particular scientific discipline at undergraduate level. Nevertheless, there have been some benefits to being part of the wider CETL community. There have, for example, been useful interactions with some particular CETLs, most notably with AIMS, our sister CETL at the University of Bristol, where a certain synergy has been apparent, particularly in learning from each other on how best to evaluate the student experience. There have also been interactions with other CETLs, such as CELS at Nottingham Trent University, which have proved helpful in sharing common ideas about Outreach activities, and the EL CETL at the University of Plymouth, which have allowed us to consider better aspects of our educational research. Although Bristol ChemLabS has also participated in networks such as the SouthWest CETL Cluster and events such as those organized by the Higher Education Academy for the science CETLs, these have proved less useful.

Question 10
Please reflect on work emerging from your CETL that has been 'transferable', i.e. useable beyond the home audience for which it was originally developed. (You may wish to comment in terms of materials produced, a community created, understandings that CETL work has illuminated and which are useful to others, etc) (1000 words maximum) It would be useful to hear 'messages' and lessons learnt that you would like to continue to be disseminated.

In terms of laboratory-based undergraduate chemistry, the DLM concept is transferable to any institution in the UK or worldwide which has an undergraduate chemistry programme since all chemists have to develop certain key skills and practical knowledge. Whilst the details of the content may differ, *ie* the particular nature of the experiments and assessment, the ethos behind the DLM (see answer to Questions 2 and 3) is fully transferable and ChemLabS has sought to disseminate both in the UK and abroad by means of conferences, lecture presentations and publications (see 1*v*). More recently, the commercial arrangement with Learning Science Ltd (see answer to Question 4) has resulted in the Foundation LabSkills product (http://www.labskills.co.uk/university.php) designed specifically to support foundation level laboratory chemistry teaching in higher and further education in the UK and overseas.

Another area in which ChemLabS developments have had a very significant impact has been with schools through the production and subsequent sale and distribution of the A-Level DLM (A-Level LabSkills) which is designed to support the practical component of all A-Level and IB chemistry curricula. Three product lines are now available to directly support schools, teachers and students, the revenue from which is a key aspect of future ChemLabS sustainability (see answer to Question 4).

Much of the Bristol ChemLabS Outreach experience is also directly transferable to other institutions. Reference has already been made to the concept of the School Teacher Fellow and its adoption beyond Bristol, and the operation of the ChemLabS Outreach Programme in a financially sustainable

way offers a model for others to follow (see answer to Questions 4 and 5).

The DLM concept has also had a profound impact on postgraduate education and training in the two recently inaugurated, EPSRC-funded Doctoral Training Centres at Bristol (Chemical Synthesis and Functional Nanomaterials) as described in part of the answer to Question 12 below.

Furthermore, it was envisaged from an early stage of the ChemLabS programme that whatever worked for chemistry as a discipline should also work for any other laboratory-based science and the post of 'ChemLabS University Teacher Fellow' was established to facilitate this transfer. Thus, after seeing the DLM in action in Chemistry, the Department of Biochemistry at Bristol were successful in raising external funding for eBioLabs (through JISC) designed to deliver a DLM to support the first year biochemistry laboratory. This was introduced in October 2008 and has transformed the way in which the Biochemistry teaching laboratories operate. Thus the current ChemLabS University Teacher Fellow, Dr Gus Cameron, who works in Biochemistry, states: "*eBioLabs has been an unqualified success. Building on the groundbreaking work of the ChemLabS CETL allowed us to develop and deploy a DLM within a short space of time in the confident knowledge that we would improve the students' experience of practical biochemistry. Staff are reporting that the better prepared learners are achieving more in the laboratory and students find the DLM logical, intuitive and easy to use. We have therefore shown that the DLM model developed by ChemLabS is fully transferable between chemistry and biochemistry and we believe that similarly dramatic results could be achieved in all of the biosciences.*" In fact, so successful has eBioLabs been that the Department of Physiology and Pharmacology are now developing a DLM to support their first year laboratory teaching which will be available from October 2010.

Question 11
How will the work and achievements of your CETL continue after HEFCE funding ends (1000 words maximum)? Please reflect on how far you think CETL work has become embedded in your institution or discipline and indicate if any structures have been put in place to ensure its legacy is not lost (1000 words maximum)

The fact that Bristol ChemLabS is subject specific and exists entirely within the School of Chemistry at the University of Bristol means that all of its activities in relation to the teaching laboratories and providing the best possible teaching and learning environment for chemistry undergraduates will continue after the formal end of the CETL programme. Not only is this part of the School's mission statement, it is possible because the new laboratories are now built and equipped, the DLM has been constructed and implemented for all year groups, and staff seconded to the CETL are, for the most part, back on the School's salary budget. As such, ChemLabS work is now thoroughly embedded not just within the School but also within the University to such an extent that its legacy is in no danger of being lost. Nevertheless some recurrent costs, particularly in terms of equipment replacement, and new DLM initiatives are likely to exceed what the department can easily afford and future sources of revenue will be needed to maintain excellence in all aspects of the teaching laboratory operation. This is a key aspect of the long-term sustainability programme for ChemLabS and has been addressed through both a successful corporate and alumni focused fundraising effort and also through commercial ventures associated with the LabSkiils initiative with Learning Science Ltd.

Question 12
Do you think there are any emerging aspects of your CETL activity that will have greater importance in the future? (600 words maximum)

Yes, without doubt, and in addition to some of the points made in the answers to Questions 10 and 11. The ChemLabS Programme was originally designed to enhance teaching and learning in undergraduate chemistry laboratories and this has been delivered through a comprehensive reappraisal of all aspects of the laboratory experience and, in particular, through the development of the DLM. Originally the DLM was envisaged to be an interactive, web-based laboratory manual with additional rich media content to enhance student learning such as video and interactive simulations as well as online assessment, feedback and safety training (see answer to Question 3). As the DLM developed it became clear that the student experience could be further enhanced by having a collection of online tutorial material to support related aspects of learning particularly in relation to the many analytical techniques which the students encounter in the laboratory. This has now started to develop into a much more comprehensive resource of value not only to the students whilst in the laboratory (including pre- and post-laboratory work), but also in relation to the lectures they have which relate to these techniques. Consequently, the DLM is now becoming a resource which

supports not just laboratory teaching and learning but also a resource to support many other aspects of curriculum delivery. Moreover, based in large part on the ChemLabS experience, the entire Bristol Chemistry undergraduate curriculum is currently undergoing a comprehensive revision, many aspects of which have been informed by developments pioneered with the DLM and based on what has been learned in the labs in general (see answer to Question 3).

Another important aspect to emerge has been the value of the DLM approach to postgraduate training. Thus within the School of Chemistry at Bristol there exist two recently funded EPSRC Doctoral Training Centres (Chemical Synthesis and Functional Nanoscience, the latter joint with Physics) which represent a new paradigm in postgraduate study. Central to this approach is a much greater emphasis on research training in the first year of study and a crucial part of delivering this training has been the development of a suite of so-called 'advanced DLM experiments'. These focus on particular advanced techniques or research methods and have drawn heavily in their style and approach from what was developed for undergraduates.

Question 13
Any other comments (600 words maximum)

All of what needs to be said about the Bristol ChemLabS CETL has already been said in the answers to all the questions above. In summary, however, we believe that Bristol ChemLabS has been a great success. It has been well run and has had the full support of the University of Bristol, has delivered on all of its original objectives, will continue to operate and innovate, has had impacts beyond undergraduate teaching and learning and in other disciplines, has established a financially sustainable and very wide-ranging Outreach Programme, and been successful in raising funds from commercial sponsors, alumni and through a commercial venture with Learning Science Ltd.